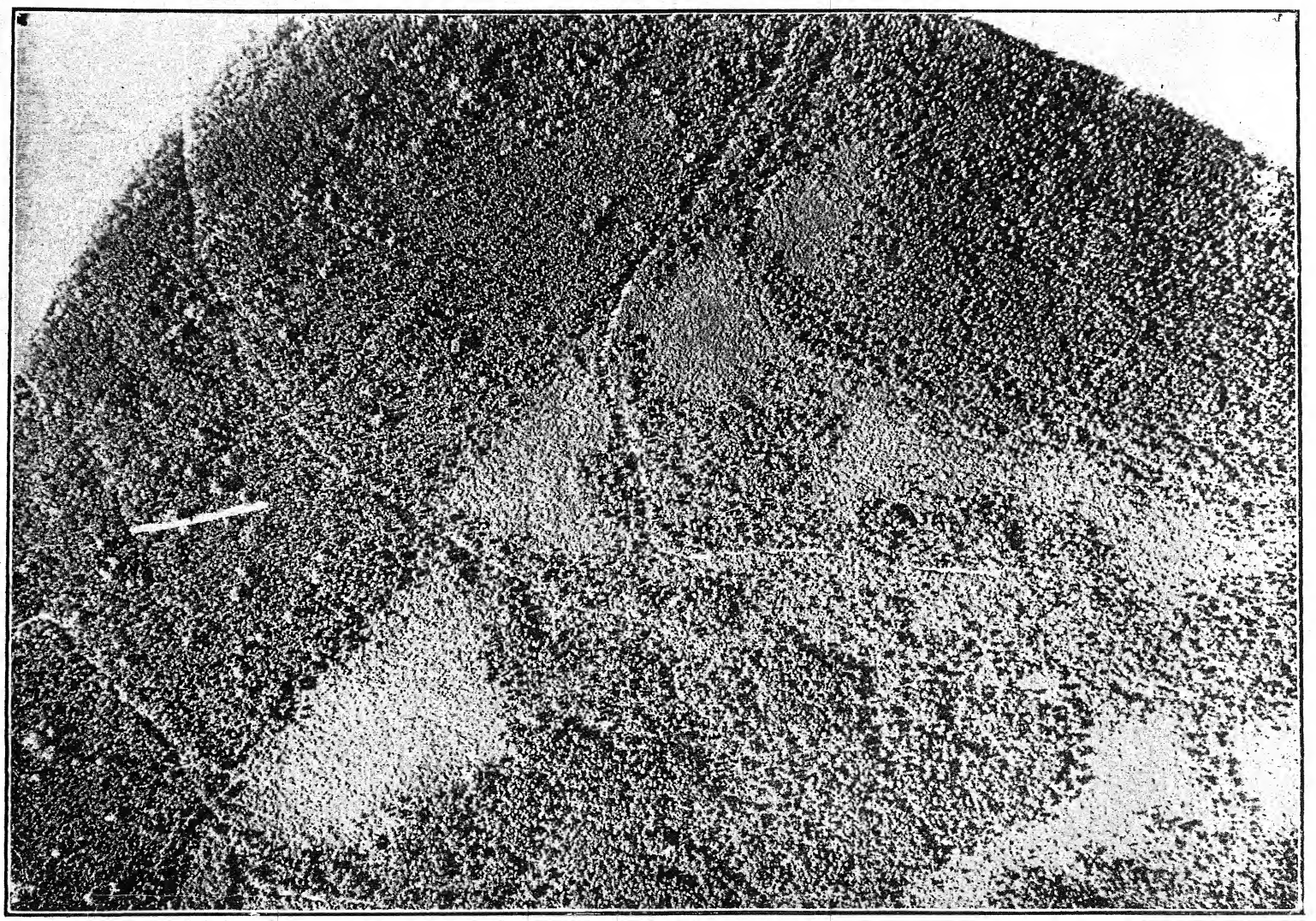

Aerial View of the Delta Forests of the Irrawaddy Delta. East bank of main Irrawaddy distributory, 12 miles from the sea, Kadonkani Reserve. On left Kanazo Forest with large Kambala (L19 variety); on right pure Kanazo Forest (L19) alternating with Mixed Delta Scrub (Byaik, L20). Scale roughly 5.7 ins. to 1 mile. Photograph taken from elevation of 10,000 feet.

THE

VEGETATION OF BURMA

FROM AN ECOLOGICAL STANDPOINT

BY

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PREFACE.

The present work has grown out of a paper dealing with the Ecology of part of the Dry Belt of Burma, by Mr. Lord and myself, which was published in the " Journal of Ecology " in September 1923 and also epitomized in the Journal and Proceedings of the Asiatic Society of Bengal. The present note was intended originally for publication as a short paper in a technical journal. Its appearance, considerably enlarged and with plates illustrative of vegetation types, in book form is mainly due to the interest which has been shown by Officers of the Indian Forest Service in Burma. An attempt has been made to render it of futher service to them by the inclusion of a chapter on the geology of Burma, written, as far as possible, from the foresters' standpoint. The publication of the work as a Research Monograph has been made possible by the moral and financial support of the University of Rangoon, to which body my sincere thanks are tendered.

It is hoped, however, that the study, brief as it is, will possess more than a local interest. In Burma one has a typical monsoon country but one in which the extraordinary variations of rainfall—from 20 to 200 inches within a few score miles—has produced most interesting changes in vegetation. The varied geological formations and the consequently varied soils are also potent factors in the ecology of the country, sometimes accentuating, sometimes nullifying, the effects of climate. Burma has too a varied physical relief, some areas rising to over 10,000 feet, and the effect of even moderate relief on tropical vegetation is too well known to need more than passing mention. The hand of man has been a far more potent factor in determining the existing types of vegetation in the country than the sometimes very scanty population would lead one to suppose, but that is a long story which must be left for future consideration.

In the preparation of this work my acknowledgments are due, first of all to my friend and former collaborator, Mr. Leslie Lord, B. A., I. A. S. To us conjointly fell the bulk of the laborious ' spade-work ' whereby the general principles underlying the ecology of Burma were first determined. More than one avenue of approach was tried by us without success and the accumulation of data involved was considerable.

The extension of these ecological principles from the Dry Belt to cover the whole of Burma has been very materially aided by the botanical notes contained in the various ' Working Plans ' prepared by Officers of the Forest Service. These volumes together with the ' Stock maps ', although printed are not available to the general public and I am much indebted to Mr. F. A. Leete, C. I. E., late Chief Conservator of Forests, and later to Mr. H. R. Blanford, O. B. E., Conservator of Forests, Working Plans Circle, for permission to study them and assistance in so doing. My sincere thanks are tendered also to Mr. C. B. Smales, Chief Conservator of Forests, who has been kind enough to read through the rough manuscripts and to place his very wide knowledge of Burmese vegetation at my disposal. I wish to thank also Mr. R. Unwin, B. Sc., I. F. S., Professor of Forestry in the University of Rangoon, for his

valued criticism. Other Forest Officers whom I should also like to mention who, in course of numerous discussions, have greatly helped me include Messrs. A. H. M. Barrington, C. R. Robbins, C. G. E. Dawkins, S. F. Hopwood and C. E. M. Kelly.

In order to save space, I have committed the rather serious crime of omitting the author's names after most of the species quoted. Every serious student, however, will have such works as Brandis's "Indian Trees" where these deficiencies can be filled.

An apology is tendered to those ecologists outside Burma who may be disappointed in finding the present work mainly descriptive. The time is not yet ripe for even a cursory account from the point of view of succession. Even in the best studied forests of the country little is yet known of plant succession and opinions on even the most salient features, such as the spread or otherwise of In, are often diametrically opposed.

Whilst this study has been in progress—from early in 1922 to the present—I have visited most parts of Burma—from Mawlaik to Victoria Point and from Akyab to Namtu and Taunggyi. At the same time it cannot be more than the merest outline of the 'Vegetation of Burma'. If it serves as a basis for future ecological work in this most interesting country or if it kindles the interest of others, its aim is achieved.

I shall be very grateful indeed for additional information, comments, suggestions and criticism. When one realizes the small proportion of Burma which has been adequately studied, and the innumerable complete gaps in our knowledge of the Vegetation of Burma, one realizes the vast field there is for ecological research—a field open to all with an interest for Nature at home.

Rangoon, July, 1924. L. D. S.

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Plates IV, V and IX are reproduced from the '*Memoirs*' and '*Records*' of the Geological Survey of India, by kind permission of the Director; Plates VIII, XXI and XXIII fig. 1 are reproduced by permission from Official Publications of the Forest Department in Burma. The photographs for Plates X, XI, XII, XIII, XV, XVI and XVIII were kindly supplied by the Sylviculturalist, Burma; the photographs for Plates I, XXII and XXIII fig. 2 were supplied by Major R. C. Kemp in charge of the Delta Aerial Survey. Professor H. Stanley Jevons took much trouble in obtaining the negative for Plate VI; Mr. A. E. Day kindly supplied the photograph for Plate XIX, fig. 1. Plate VII fig. 1 and XXVI fig. 1 are from negatives by the M. Inui Studio, Tavoy. The photographs for Plates II, III, XI fig. 2, XIV, XVII, XIX fig. 2, XX, XXIV, XXV, XXVI fig. 2, XXVII were specially taken for this work by the author. Plate XXVIII is reproduced from the 'Journal of Ecology' (vol. XI, 1923) by kind permission of the Editor and the Cambridge University Press.

I. INTRODUCTION.

For some years the writer has been struck by the absence of any comprehensive account of the vegetation of Burma as a whole and further by the extraordinary inaccuracy of the "Vegetation-maps" published both in atlases and as wall maps. With regard to the maps sometimes it seems that only the exploited areas of forest have been coloured as forest, the remainder being uniformly coloured as " grass or sparsely cultivated " or even under the heterogeneous title " woodland, grass and cultivation." In other cases the authors of the maps concerned seem to have imagined that the evergreen tropical forest must of necessity fringe the coasts and penetrate inland along the main river valleys. Such is, of course, by no means the case.

For so long the forests of Burma have been associated in the minds of most with teak and it is difficult to realize the relatively small proportion of the forests of Burma which yield teak and further the small proportion of teak in those forests classed as Teak Forests. The prominence which is now being given to some of the other magnificent timbers of Burma may serve to arouse some general interest in the forests of the country. Moreover, to describe the natural vegetation of Burma is, to a very large extent, to indicate the possibilities of progress not only in forestry but also, equally important, in agriculture.

The literature on the ecology and distribution of vegetation in Burma is scanty and scattered. As long ago as 1873 S. Kurz published his " Preliminary Report on the Forests and Vegetation generally of Pegu "[1] an account which was reproduced in substance in the Introduction to Kurz's " Forest Flora of British Burma "[2]. These accounts, excellent as they are, deal only with Lower Burma or " Pegu ", a very small proportion of the present province. Kurz's reports have been quoted at considerable length in several text-books[3]. There is a short general account of the vegetation by Capt. A. T. Gage in Sir J. G. Scott's " Burma." Other publications, dealing to some extent with the vegetation of Burma, are noted in the Bibliography at the end. The present account is based primarily on the writer's own experience. A detailed study of a critical tract has already been published in a technical journal devoted to the subject[4]. This has been supplemented to a very large extent by information gleaned from the official " Working Plans " of the Forest Reserves prepared by the Indian Forest Service. These volumes are not accessible to the general public. Unfortunately these working plans only cover a portion of the exploited or exploitable forests and of at least half the country there exists no account at all.

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[1]Government Press, Calcutta, 1873.
[2]Superintendent, Government Printing, Calcutta, 1877.
[3]Schimper, Plantzengeographie, English Translation, Oxford, 1903.
[4]Stamp and Lord, The Ecology of Part of the Riverine Tract of Burma. *Journal of Ecology*, Vol. XI, 1923, pp. 129—159.

II. THE FACTORS GOVERNING THE DISTRIBUTION OF VEGETATION.

Taking Burma as a whole two factors are of paramount importance in determining variation in vegetation. These two factors are climate (especially rainfall) and elevation. These two determine regional or major changes. If one takes an area of a few dozen or few hundred square miles, however, it is often found that the relation between the geology and soil and the superincumbent vegetation is remarkably close. As the writer has remarked elsewhere[1] " There are many places in which may be found within a stone's throw of one another typical monsoon Forests of *eng* and *ingyin;* Savannah Forest; Thorn Forest and Thorn Scrub." This is purely the result of edaphic or soil control.

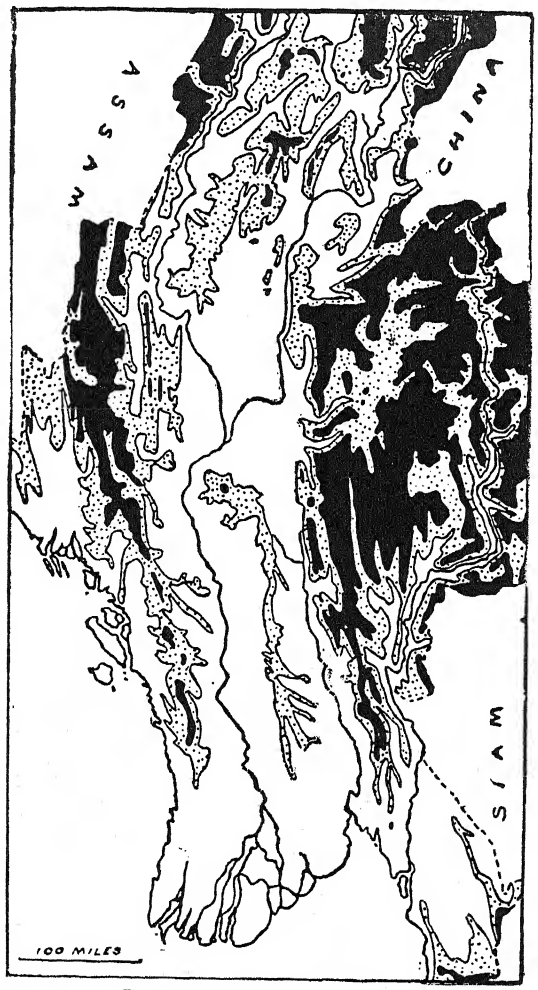


Fig. 1. The Relief of Burma.

[1] Stamp and Lord, *op. cit.*, p. 140.

A. ELEVATION.

It is convenient to consider firstly the effect of elevation since it has an extraordinarily marked effect. It is really only necessary to consider a threefold division:—

(i) land over 3,000 feet.
(ii) land below 3,000 feet.
(iii) tidal areas.

(i) Land over 3,000 feet.

The 3,000-foot contour line may be considered as roughly marking the great change in the type of vegetation above and below. In reality it is probably the " frost-line "—below which frosts never occur—which is the determining line. Teak can be grown with slight frosts but never reproduces. Hence the upper limit is lower the further north one goes. In " frost-holes " or depressions in plateau areas the dividing line may descend very low. To take one example, in all areas where soil and climate are suitable the teak tree flourishes up to roughly 3,000 feet above sea-level, but however abundant shortly below, it very rarely occurs above. This statement is true of widely separated parts of the country. From official publications the following definite records of the upward limit of teak are taken:—

Mawku 2,500, Ahlaw 2,500, Gangaw about 3,000, Kyaw 3,000, Wapyudaung 2,800 (usual) 3,100 (extreme). On the other hand it is found that although individual oaks may be found down to sea-level, the typical oak forest rarely descends below 3,000 or 2,500 feet except in frost hollows. The same statement is true of pines *(Pinus khasya)* though the pines are perhaps more usual above 4,000. The lower limit of rhododendrons is not so constant, it is just over 5,000 feet in parts of the Arakan Yomas. In addition it may be stated at once that there appears to be no true grassland[1] in Burma below 3,000 feet, though large areas of the Shan Plateau above 3,000 feet and of the Arakan Yomas are grass covered. A glance at the contour map (fig.1) shows the parts of Burma below and above 3,000 feet. This should be compared with the map showing the distribution of forest reserves, a large proportion of which were reserved for the sake of the teak.

(ii) Land below 3,000 feet (excepting tidal areas).

A great deal of the land below 500 feet, or even below 1,000 feet is cultivated. Of the remainder the whole may be described as forest-covered but the rainfall determines the range from evergreen rain forests, through monsoon and savannah forests to thorn forests and thorn-scrub or even to semi-desert. It must be noted, however, that the latter is an *impoverished type of woodland and not an impoverished grassland.* It is an important general principle that both woodland or forest and grassland degenerate to desert with lack of rainfall or other moisture. It is in the area of Burma below 3,000 feet that are found all the forests at present exploited.

(iii) Tidal areas.

The most important tracts are the seaward part of the Irrawaddy delta, the lower islands of the Mergui Archipelago and South Arakan.

[1] See remarks below on "seral" communities.

B. **CLIMATE** (especially rainfall).

The climate of Burma—at least of the area below 3,000 feet—is essentially a woodland climate. It would be difficult to find a country which proved more conclusively the argument of Schimper that woodland and grassland climates are essentially dissimilar and that woodland does not pass into grassland by decrease of rainfall. Grass demands essentially a surface water supply, usually only to be afforded by frequent light showers during the growing season. Trees and shrubs on the other hand draw upon a deep seated water supply, the actual season when the rain falls is less important provided the moisture reaches the lower layers of the soil. It should be noted that in this respect most bamboos rank as trees. In the drier parts of central Burma the rain falls during a few heavy storms and the surface soil is rarely moist for long, a condition by no means suitable for the adequate growth of grass.

It is unnecessary to state here that Burma is essentially a monsoon country. The rainy season lasts approximately from June to September or October. Except in the extreme south (Tenasserim) the remainder of the year is almost rainless. November, December and January may be said to form the cool season, in February the temperature as a whole increases, reaching a maximum in April or May. Although a considerable area of Burma lies to the north of the Tropic of Cancer, the whole of Burma as far as its vegetation is concerned belongs to the tropical zone. The so-called "warm temperate forests" of the north are due to elevation, on lower ground typical "monsoon forest" stretches as far north as does the low ground. It must, however. be recorded that the northern limits of many well known monsoon forest trees such as Teak and Pyinkado are reached and passed.

A rainfall map for the rainy season differs so little from an annual rainfall map that it is only necessary to consider the one. In using an annual rainfall map it is merely necessary to remember that the greater part of the rain falls in the rainy season from May to October.

In the course of this investigation it has been found that there are two rainfall lines of paramount importance. They are the lines of 40 inches and 80 inches. Climatologically these two lines divide Burma into three parts;—

(i) Area with less than 40 inches of rain.

This is the Dry Belt of Burma; indeed the Dry Belt is most accurately defined as that area which receives less than 40 inches of rain. The Dry Belt owes its existence to the presence of the Arakan Yomas, cutting it off from the rain-bearing S. W. Monsoon. Most of the rain which actually falls does so in a comparatively few heavy downfalls on a few days in the Wet Season. The rainfall ranges as low as 20 inches (Sale has 20.63 ins.). A rainfall of less than 40 ins. is, in Burma, insufficient for the proper growth of forests. There are, of course, a number of trees such as those planted as " shade trees " which reach a large size even in the Dry Belt, but they do not grow as natural Forests and many of them are not native species. Examples of individual trees thriving in the Dry Belt are *Tamarindus indicus* (Tamarind), *Pithecolobium saman* (Rain tree) and *Mangifera indica* (Mango). There are no exploitable forests of teak. A few stunted teak may occur near the borders. The production of other timber is limited to posts for the main

props of native huts. Cutch is the characteristic product of the region. With a rainfall of less than 40 inches rice will not grow without irrigation but all the Dry Zone Crops—cotton, sesamum, ground-nuts, millet etc.—flourish in average years.

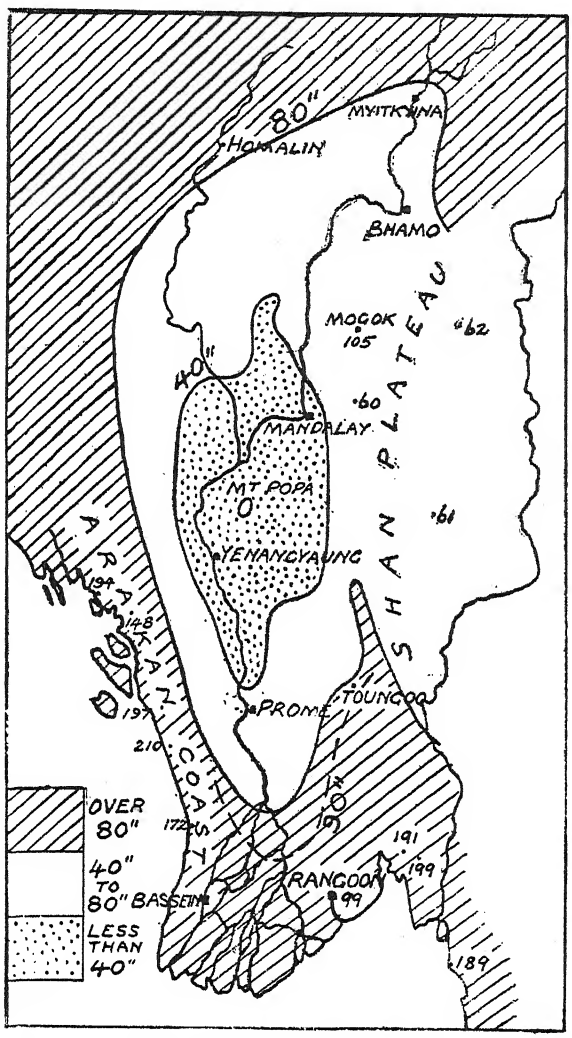


Fig. 2. The Rainfall of Burma.

(ii) Area with a rainfall between 40 and 80 inches.

This is the area of the Monsoon Forests—forests which lose their leaves during the Dry Season, usually shedding them about January or February. In this and in the Dry Belt the new leaves appear about a month before the rains break in earnest, flowering also takes place generally shortly before the rains. It is the region of the great teak forests and many of the other valuable timbers come from this region. For some time the writer has hesitated whether to take the isohyet of 80 inches or of 90 inches as the limiting line. Over most of the country it makes

Fig. 3. The Reserved Forests of Burma (generalized) showing their occurrence between the rainfall lines of 40 and 80 inches, the main exceptions being the Delta Swamp Forests (Pinle-Kanazo), a large area at the southern end of the Pegu Yomas (mainly Pyinkado), and the Evergreen Forests of Tenasserim.

very little difference, but in the valuable teak-yielding area of the Pegu Yomas it is true that many important forests occur when the rainfall is rather over 80 inches. It may be noted here that most of the Shan Plateau falls within this rainfall belt—so far as one can judge from the scanty rainfall records—and it must be under these climatic conditions that the pine and oak forests and the Shan grasslands flourish.[1]

(iii) Area with a rainfall of over 80 or 90 inches.

This is the region of the evergreen forests and where it is too damp for teak to flourish. In plantations teak will indeed grow rapidly but the trees in many cases become hollow and fluted early. In natural forests its place, therefore, is taken by evergreen trees more fitted to the climatic conditions. Though many parts, especially in Tenasserim, are clothed with some of the tallest forests in Burma there has been little exploitation. The timber is usually hard—a feature characteristic of the tropical evergreen forests as a whole.

C. GEOLOGY AND SOIL.[2]

Everywhere, to the trained eye, geology—and the resultant soils—is seen to be the controlling factor in the local distribution both of forest types and of individual species. To some extent climate and soil counteract one another. As the writer has described and illustrated elsewhere[3] the same formations tend to reappear on different soils under different climatic conditions. Thus the *Acacia* Scrub is found on physically dry Irrawaddian sands with a rainfall of 25 inches and physiologically dry Pegu Clays with a rainfall of 35 inches, whereas the physically dry Irrawaddian sands with a rainfall of 35 inches produce moderately good trees in an open Monsoon Forest of "Indaing" type. Local geology which can only be known as a result of detailed mapping will undoubtedly be of great value in forestry at a later date in Burma. In an appendix is given a list of geological maps available for the forester's use at the present time. Even taking the country as a whole, the geology has an important influence. It may be outlined here.

THE GEOLOGY OF BURMA.

East of Burma. Forming the highlands of the east of Burma—that is the whole of the Shan Plateau, Karenni and with a southern extension to form the whole of Tenasserim—is a complex of *old hard rocks*. This area is bounded on the west by a comparatively narrow belt of old gneiss, yielding very little soil. In the north (Mogok) much of the Shan Plateau is formed of alternating bands of gneiss and limestone. Further south old sedimentary rocks cover most of the country and of these the

[1] Exposed situations on the edge of Plateau naturally receive a much heavier rainfall—for example Thandaung with 200 inches.
[2] See also Section IV and appendix.
[3] Stamp and Lord, *op. cit.*, pp. 153-4, Pl. I.

Plateau Limestone is the most widely spread and its existence seems directly responsible for the Shan Grasslands. In the massif of the Shan States there are also old filled-up lake basins (Lake Inle is a remnant of such) giving rich alluvial tracts grading into marshes in the centre.

The following rock types and soils may be looked for in this region of old hard rocks:—

Tenasserim (Tavoy and Mergui.)

1. Granite, forming most of the high land over 3000 feet and considerable areas of lower land as well. The granite often weathers deeply to a coarse sandy soil and when unprotected by forests the heavy rains may easily wash away whole hillsides, exposing the bare granite. When protected from the destructive action of rain the soil may become rich in humus and supporting high evergreen forest. Such granitic soils are often rich in plant food especially potash. Other granite ridges yield very little soil and the bare rock is very near the surface or actually exposed. The granite masses of Tavoy are generally from one to five miles in width and much elongated in a north and south direction. Most of the bold hilly islands of the Tenasserim coast are of granite and rocky beaches are formed.

2. Hardened shales or phyllites of the Mergui Series occupy a large part of the remainder of Tenasserim. Though hard they weather much more easily than granite and give rise to lower ground. The soil is heavier and more clayey than that from the granites. The forest trees are said to be shorter but the growth denser. When worn down to sea-level, the Mergui Series gives rise to low islands surrounded by mangrove and other swamp forests.

3. Limestone occurs on a few isolated hills and islands only.

4. Late Tertiary Sandstones and Shales occupy depressions amongst the older rocks, as around Kyaukmadaung and Myittha and the lower valley of the Tenasserim River. Not only are these lower areas protected by the surrounding ranges from rain bearing winds (compare Kyaukmadaung 140″ and Tavoy 198″) and receive a lower rainfall but it seems that, the strata being nearly horizontal, water-logging occurs during the rains whilst in the dry weather the water-table falls very low. The forest is certainly of a much drier type than one would expect. Certain alluvial tracts behave in the same way.

5. Alluvium around the coast affords cultivable land and, nearer the sea, swamp forest.

Tenasserim (Amherst.)

1. and 2 occur as in Tavoy.

3. There are much larger areas of limestone, often forming steep sided hills and ridges and yielding very little soil, hence dry forests on the ridges.

4. There are large areas of alluvium round the Salween River and its tributaries, and varied alluvial soils are to be expected, some well drained and very fertile.

Federated Shan States.

1. Crystalline Gneiss and Granite. A long strip of crystalline rocks bounds the Shan States on the west and forms the edge of the plateau from just south of Mandalay to Martaban. The same ridge continues from Sagaing northwards. Except for exposed places like Thandaung the rainfall is less than in Tenasserim and decreases gradually from south to north, reaching as low as 30″ near Sagaing. The crystalline rocks form very little soil and large areas of bare rock occur with the result that the vegetation is much poorer and drier than on other neighbouring rocks.

2. Limestone occupies more country than any other rock in the plateau and occurs over most of the plateau land. It gives rise, however, to several very distinct types of soils:—

(a) Bare limestone with very little soil and where the trees root in the cracks in the limestone, and numerous crags are seen everywhere. Good tree growth may occur on such areas (Teak near Hsipaw, Indaing near Zibingyi).

(b) A dark red, very ferruginous clayey soil, occurring especially on level areas. This soil represents the residue when all the lime has been removed in solution. It is a very common soil on the plateau and is often very deficient in lime. Moreover drainage is often bad and the result is scrub vegetation, grassy areas and marshes.

(c) A modification of the latter occurs when the drainage is good and much humus has collected giving a dark rich loamy soil which is very good indeed.

3. Sandstones occur both as considerable areas resting on the limestone and as long strips folded with the other rocks. When very hard the soil may be stony and poor, softer rocks yield a good loamy soil.

4. Contorted and puckered shales of the Nyaungkangyi and other old series. When rainfall is light (e. g. between Sedaw and Zibingyi, Maymyo line) these yield a very poor soil, but with a heavier rainfall they may disintegrate to a rather clayey loam (hills north of Maymyo).

5. Late Tertiary, occupying basins. Compare Tenasserim.

6. Mogok Gneiss and Crystalline rocks occur to the north-east. Bands of limestone are numerous and the rocks more varied than 1, so that soils are often good.

Arakan Yomas. As a narrow strip forming the core of the northern part of the Arakan Yomas is another belt of ancient rocks, including gneisses.

1. Kanpetlet Schists. Little is known of these rocks and the soils they yield.
2. Hardened shales with sandstones occupy the major portion. The Arakan Yomas consist largely of highly folded rocks, many of which are, however, as late as Tertiary. The harder rocks yield a very stony soil, made richer by humus in valleys. This soil supports the open oak forests described below. On the whole the heavier the rainfall the denser the growth.
3. Oval or round bosses of serpentine occur down the eastern flank from Somra Tract to Bassein. They probably yield, as elsewhere, very little soil and are likely to be clothed with a highly specialized dwarf-shrub or herbaceous vegetation.

Central Basin. Between these two areas and comprising roughly the Chindwin-Irrawaddy and Sittang Valley with the intervening Pegu Yomas as well as the foot-hills of the Arakan Yomas and the hills on each side of the Chindwin, is a large area of Tertiary Rocks comprising clays, shales, sandstones and loose sands. Geologically these Tertiary Beds may be classed as follows:—

3. Irrawaddian—mainly coarse sands.
2. Peguan { Sandy beds. / Clays. / Sandy beds.
1. Eocene—alternating belts of clays and sandstones with thin limestones in the south.

It may be further noted that nearly all the beds are sandier in the north than in the south. Occupying the broad valley floors are wide stretches of alluvium.

This is a typical area of young soft rocks and any elevations above 2500 feet are exceptional.

Pegu Yomas.

The *Pegu Yomas* consist of a folded mass of Tertiary rocks—almost entirely Peguan. In the south the folding is bold and simple but northwards the main folds split up into a number of small ones and become very complex. The main folds run north and south, so that in the simpler parts the Pegu Yomas consist of long bands of different types of rock, the outcrops having a steep scarp slope on one side and a gentle dip slope on the other. The direction of the dip controls the drainage and, with the soils, controls the type of forest. This is further illustrated by Fig: 11 in section IV. The rocks and soils are as follows.

1. Coarse, loose sands (mainly Irrawaddian) occur as a fringe on the north-east and north-west just where the hills fade away into the plains of the Irrawaddy or the low-ground of the Sittang Valley. This is the typical 'Indaing' soil of the borders of the Dry Belt, stretching even as far south as south Toungoo with 85".
2. Moderately fine sands and soft sandstones, standing out as ridges such as that west of the Kodugwe Valley, and the main crest of the Yomas. The scarp slopes may be steep but the long dip slopes afford excellent loamy and sandy soil, well-drained.
3. Alternating sandstones and shales giving on the whole good loamy soils with local variations due to special bands. This is the most common type and in the north of the Pegu Yomas, where the folding is complex the beds are so mixed up as to give this type of soil (e. g. most of Pyinmana.)
4. Shales, sometimes hardened or rubbly. These give rise to valleys often with a stiff clay soil, or a poor shaley soil and capable of supporting only a dry type of forest. The Kodugwe Valley is an example. A common type from Prome to Insein.
5. Laterite. True cellular Laterite develops in the wetter southern half of the Yomas, especially on (3) above as around Rangoon.
6. *Chaung* Alluvium borders most streams of any size.
7. On the western side of the Yoma there is the great stretch of the Irrawaddy alluvium which in depth is often a stiff blue clay. In the laha country (Myitmaka Valley) the streams coming down from the hills have deposited over this a sheet of varying thickness of sand.

The Eastern Foothills of the Arakan Yomas, from Bassein to Pakokku District.

Again the folds run roughly north and south and there are long narrow outcrops of alternating sandstones (forming hills) and clays (forming valleys).

1. Coarse loose sands (Irrawaddian) occur especially towards the plains.
2. As in the Pegu Yomas.
3. As in the Pegu Yomas, but often near the more intensely folded Arakan Yomas the rocks tend to be hardened and soil more stony. supporting only dry types of forest.
4. As in the Pegu Yomas.
5. As in the Pegu Yomas.
6. Limestone occurs as narrow bands in the southern part. Its presence in the midst of clay may considerably improve the soils derived from the latter.
7. Alluvium as in the Pegu Yomas.

From the Pakokku District northwards to the Somra Tract (The Chindwin Valley.)

Here the same long north and south outcrops occur but most of the beds are more sandy; dry coarse loose sands are common on many different horizons; bands of purplish or mottled clays are common but interbedded shales and sandstones far less so.

1. Coarse loose sands, often pebbly (Eocene, Peguan and Irrawaddian) cover large areas at both low and high levels (e. g. ridges and dip slopes of the Pondaung and Ponnyadaung ranges) hence a number of the ridges are very dry (see also Section IV.)
2. Fine grained sandstones occur but are less abundant.
3. Alternating sandstones and shales or sandy shales occupy a much smaller area but afford good loamy soil when they do occur.
4. Purple or mottled purple and green shales. These beds tend to be alkaline or ferruginous and infertile. Normal shales giving stiff clay soils also occur.
5. Alluvium—in addition to ordinary alluvium some stretches of old gravel also occur as in the Gangaw Valley.

The Mu-Chindwin Divide.

As in the last group but volcanic rocks occur and volcanic soils should be looked for.

The Mu-Irrawaddy Divide.

The rocks and soils combine to some extent the characteristics of the Chindwin Valley with the Shan States massifs. Large stretches of loose sands, nearly horizontal and affording swampy areas where slightly clayey, occur in the upper Irrawaddy Valley. Considerable areas of crystalline rocks also occur.

The Dry Belt.

In this area the rocks are little folded and tend to be soft and easily washed away.

1. Coarse, loose sands, often gravelly (Irrawaddian) cover large areas. They are usually ferruginous and often tend to form 'hard pans.' Where the rainfall is sufficient they afford the typical Indaing Soil but in the drier parts form the well known large stretches of barren, broken ground around Yenangyaung, Sale etc.
2. Finer sands and sandstones, mixed with shales (Peguan) often hardened and standing up as lines of hills—such as those which border the river from Prome to Minbu and again near Pagan. The soil afforded is often loamy and good but where the hills are steep may be stony and poor.

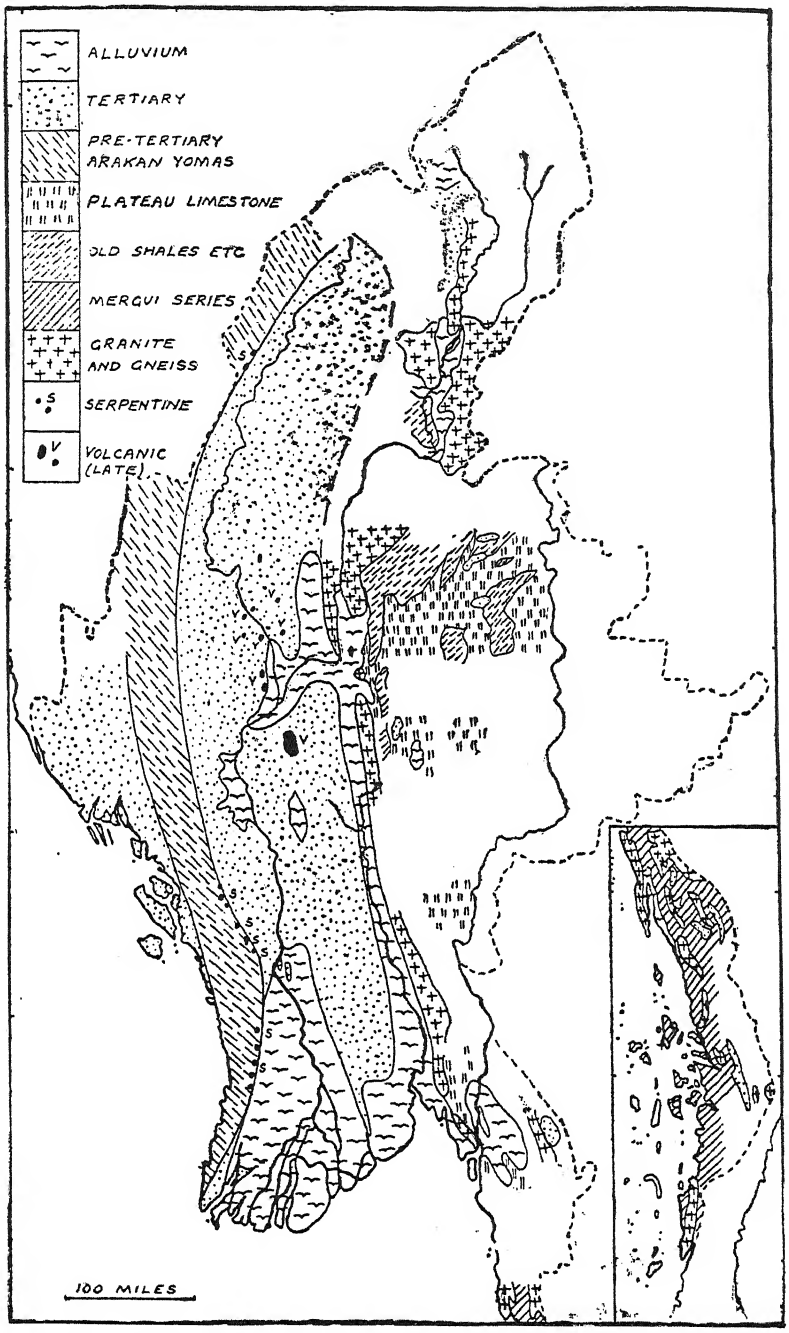


Fig. 4. Geological Sketch map of Burma, reduced from the maps published by the Geological Survey of India. The blank areas have not been mapped geologically but consist mainly of old rocks, with limestone predominating.

3. Shales with bands of soft sandstone (Peguan). Such beds are often full of gypsum and so afford a very alkaline and poor soil—often there really is no true soil. Hence the driest and poorest vegetation in the country as a Yenangyat, Singu, Minbu, etc.

4. Clays and shales (Peguan). Where the rainfall is more than about 35 inches these weather to a very stiff clay soil; where the rainfall is less than 35 inches, the alkaline salts become concentrated in the surface soil as little hard white concretions and the soil is extraordinarily alkaline and infertile.

5. Plateau Gravel. Large stretches of red, ferruginous gravel occur, especially capping the low cliffs on either side of the River Irrawaddy. Very similar is the red soil of such broad valleys as around Natmauk but this soil is usually cultivated.

6. Alluvium covers huge areas—as to the west of the river near Yenangyaung, and in Pakokku and Myingyan Districts.

7. Volcanic rocks. Forming isolated hills of which Popa is the finest example are numerous extinct volcanoes. The majority of the others, apart from Mount Popa, are in the Lower Chindwin, around Monywa.

Arakan Coast. The Arakan Coastal Strip consists of folded and hardened Tertiary rocks. The folds again run roughly north and south. The rocks do not vary greatly from those of the Pegu Yomas but are all more hardened and so, instead of affording good loamy soils, form very poor stony soils. Probably, too, the accumulation of good soil is hindered by the heavy rainfall.

III. THE MAIN TYPES OF VEGETATION.

In the present state of our knowledge the natural vegetation of Burma may be divided into a number of types. Many of these types are far from well-known, others can at least be fairly well defined. The provision classification suggested is as follows:—

I. *Mountain Vegetation* (above 3,000 feet or the Frost line.)

- M1 Oak Forest.
- M2 Pine Forest.
- M3 Rhododendron Forest.
- M4 Bracken Brake.
- M5 Mountain Bamboo Brake.
- M6 Mountain Grassland.

II. *Lowland Vegetation* (below 3,000 feet.)

- L1 † Evergreen Dipterocarp Forest.
- L2 † Wet Evergreen Forest (Northern type.)
- L3 † Mixed Cane Brake.
- L4 † Bamboo Brakes.
- L5 † Pyinkado or Semi-evergreen Forest.
- L6 † Moist Teak Forest.
- L7 *† Dry Teak Forest.
- L8 † Pyinma Forest.
- L9 *† Semi-Indaing.
- L10 *† Indaing.
- L11 * *Diospyros* Forest.
- L12 * Dry Deciduous Forest without Teak.
- L13 * Than-Dahat Forest.
- L14 * Sha-Dahat Thorn Forest.
- L15 * Sha Thorn Scrub.
- L16 * *Zizyphus* Thorn Scrub.

L17 * *Euphorbia* Semi-Desert.

L18 Valley Swamp Forest.

L19 † Kanazo Forest.

L20 † Mixed Delta Scrub.

L21 † True Mangrove Forest.

L22 † Beach or Dune Forests.

L23 Salt-marsh Vegetation.

L24 Fresh-water Swamp Vegetation.

L25 Lake Vegetation.

III. *Seral Communities.*

S1 * Kaing Grassland (Sandbanks.)

S2 * *Combretum* Hedgerow Community.

S3 * Riverside and Village Parkland.

S4 † Ponzos.

In the above lists:—

† Signifies that the type has been recognized and described in various official publications of the Forest Service.

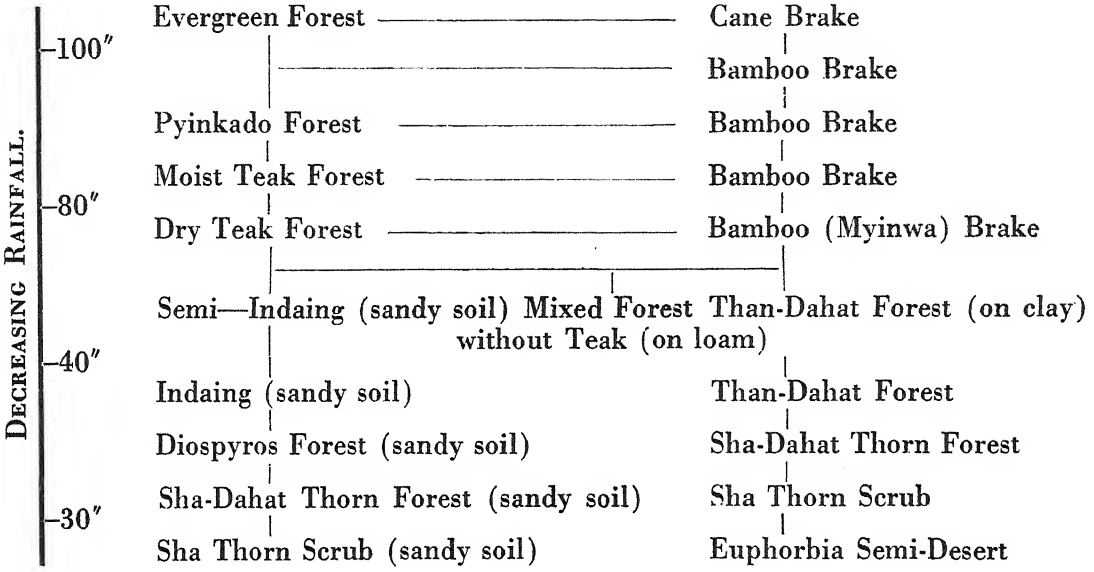
* Signifies that the type has been studied by the writer, or by Stamp and Lord, and that the bulk of the information is from their observations.

Types not marked are very imperfectly known and descriptions are either from the writer's own observations or have been collected from widely different sources.

It will be noticed that the Lowland types (sea-level to 3,000 feet) range from Evergreen Forests (L1—L3) through Monsoon Forests (L5—L10), Savannah Forests (L11—L13), Thorn Forests (L14) to Thorn-Scrub and Semidesert (L15—L17). No L16 is probably a seral community. The position of L4 is doubtful. If one regards bamboo as a grass the areas of Bamboo-Brake represent the result of the successful struggle of grassland against high forest, a struggle which has doubtless been assisted by man.

The mutual relationships of the main types of lowland vegetation are shown in the annexed table. The relationships are fairly simple.

It is freely admitted that the classification of Mountain Vegetation is totally inadequate.



Notice that with a very high rainfall, soil has little effect[1], but with a rainfall of 40″ and less its influence is paramount. Even in regions as far south as the Rangoon Hills Forests (rainfall about 95) we note that Evergreen Dipterocarp Forests occur on loams, Moist Teak Forest on a comparatively poor soil on Sandstone, whilst a type of Dry Forest occurs on physiologically dry clay bands at the heads of streams.

A few words are needed here in praise of the magnificent pioneer work of S. Kurz. One cannot help being filled with admiration, when reading his " Preliminary Report", not only for the immense amount of work involved but also for the very clear and comprehensive view he obtained of the vegetation as a whole. As his Report is now out of print it will be of advantage to reproduce his classification:—

[1]Though Indaing occurs on hill summits with very poor soil even in Tenasserim.

ORIGINAL VEGETATION.

	Climax Communities (Classification here used).
A. Forests.	
AA. *Evergreen Forests.*	
1. Littoral Forest	
a. Mangrove jungles	L 21
b. Tidal Forest	L 19 ?
2. Swamp Forests	L 18
3. Tropical Forests	
a. Closed Tropical Forests	L 1
b. Open Tropical Forests or Moist F.	
4. Evergreen Hill Forests or Temperate F.	
a. Drier Hill Forests (3000—7000 feet)	M 1
b. Pine Forests (3000—7000 feet)	M 2
c. Damp Hill Forests (3000—6000 feet)	M 1
BB. *Deciduous Forests.*	
5. Open Forests	
a. Hill Eng Forests	L 9—L 10
b. Eng or Laterite Forests	
c. Low Forests	L 9—L 10 var.
6. Mixed Forests	
a. Alluvial Mixed Forests (on alluvium)	
aa. Lower Mixed Forests	L 8
bb. Savannah Forests	S 4—S 6
cc. Beach Jungle	L 22
b. Upper Mixed Forests or Teak Forests	
aa. Moister Teak Forests	L 6
bb. Drier Teak Forests	L 7
7. Dry Forests	
a. Mixed Dry Forests	L 11
b. Sha Forests	L 14
c. Hill Dry Forests	—
B. Savannahs and Low Natural Vegetation.	
AA. Land Vegetation.	
8. Bamboo Jungles	L 4
9. Savannahs	S 4
10. Natural Pastures	
a. Long-grassed or Jungle Pastures	L 9—L 10 open spaces.
b. Short-grassed or Lowland Pastures	L 24 part.
c. Hill Pastures	M 6
11. Riparian Vegetation	
a. Vegetation of Rivers with Sandy or Clayey Beds	—
b. Vegetation of Rivers with Rocky Beds	—
BB. Vegetation of Swamps and Waters	
12. Sweet-water Vegetation	
a. Vegetation of Swamps	L 24
b. Vegetation of Lakes and other Stagnant Water	L 25
c. Vegetation of Running Waters	—
13 Salt-water Vegetation	
a. Vegetation of Tidal Swamps Salt Lakes etc.	L 23
b. Vegetation of the Sea	—

VEGETATION OF CULTIVATED OR LATELY-CULTIVATED LANDS—SERAL COMMUNITIES.

1. Vegetation of Agrarian Lands	
a. Lower Agrarian Lands, as Rice-fields	—
b. Upper Cultivated Lands (Taungyas) turning after desertion into Ponzos and Jungles	S 4
2. Village Vegetation	
a. Native Gardens, Waste Places etc.	S 3
b. Village Vegetation itself	
3. Naturalised Plants	—

This comprehensive classification was somewhat simplified in the introductory chapter to Kurz's later work (Forest Flora of British Burma), only the forests being considered in any detail. The following plant-formations, included in the present paper, are not included by Kurz:- M3, M4, M5, L2, L3, L5, L12, L13, L15, L16, L17. The writer has not considered here the specialized provinces embraced in Kurz classification viz. 11a, 11b, 12c, 13b, II. 1a. After careful consideration the writer is forced to consider many of the apparently natural formations as seral communities[1], including the patches of grassland in the Indaing, and many of the " Savannahs " with Elephant grass since he believes the latter are all transitional stages between the Kaing or Elephant grass jungles of the recently formed sandbanks of the River Irrawaddy to the high forest which is the natural vegetation, on climatic grounds, of the country.[2]

An immense amount of detail, and very long lists of plants are given by Kurz and every serious student of the subject is referred to his works.

In the descriptions which follow figures in brackets thus:—(7), refer to the Bibliography.

MI The Oak Forests (*including the Temperate Rain Forests of the North Eastern Frontier; Kurz: Damp Hill Forests and Drier Hill Forests; Thite of Burmans, Quercus-Castanopsis Association.*)

Plates II and III.

DESCRIPTION. The type of forest which commences about 3000 feet or rather less is characterized by several species of *Quercus*, collectively known in Burmese as Thitcha. It is an evergreen forest, but varies greatly in size of the constituent trees. The most characteristic species are *Quercus spicata, Q. brandisiana, Q. serrata* (these from the Arakan Yoma Forests), *Q. helferiana, Q. mespilifolia, Q. fenestrata* (these from Mogok etc.) *Q. pachyphylla* and *Q. thomsoni* (these from the Patkoi Hills); *Q. serrata* is also the common oak of the Maymyo plateau. Almost equally characteristic are chestnuts *(Castanopsis* spp.*)* Others recorded from the North of Burma include *Ilex* spp, *Prunus* spp, and *Ficus elastica;* from the North-east (Mogok, Shan Plateau Forests) *Schima, Albizzia, Salix tetrasperma, Cicca macrocarpa, Bridelia retusa, Barringtonia racemosa* and *Kydia calycina* whilst a yew *(Cephalotaxus griffithii)* is common in the dense shade. *Wendlandia glabrata* also occurs and *Alnus nepalensis* often becomes the dominant tree about 4000 or 5000 feet. Similar forests occur on the hills east of the Sittang in the neighbourhood of Toungoo.

Several points of general interest were noted by the writer when studying these Oak Forests on the Arakan Yoma divide between the Prome and Sandoway Districts and also on the Shan Plateau between Maymyo, Lashio and Namtu. In both cases but especially in the former area, the very natural and often gradual upward passage from the Indaing is to be noted. Even on the Maymyo Plateau, 3300 feet, the few

[1] "Seral" is the word used by the great American ecologist, F. E. Clements, in his monumental work "Plant Succession" (Carnegie Institution, Washington 1916) to denote natural or semi-natural vegetation which has not yet reached the normal climatic "climax" community of the locality in question.

[2] Many areas of "savannah" land—as in the "la-ha" country west of the Pegu Yomas—are the result of over-exploitation of forests aided by fire and inundation.

trees surviving from lower altitudes are species of the Indaing *Pentacme suavis* (ingyin), *Shorea obtusa* (thitya) and *Melanorrhoea usitata* (thitsi) (7). The Oak Forests on the Arakan Yoma ridges receive the full force of the rainy South-West monsoon. The forest is mostly very open, the trees gnarled, stunted and wreathed in lichens and mosses, and the undergrowth is mainly grass. (Plate II, fig 1 and 2) The Oak Forests of the Shan Plateau suffer less from strong winds and the trees are of a better shape and growth is thicker (Plate III, fig 1.) Some of the level areas are grass covered or occupied by swamps but more typically have a vegetation of stunted bushes and hence the characteristic scenery depicted in Plate IV fig 1, which although taken 30 miles outside the Burmese frontier illustrates the type. On such level stretches the Plateau Limestone, which forms the greater part of the Northern Shan States, is deeply covered with a dark red residual soil which is badly drained and curiously deficient in lime. Hence the scrub vegetation. The effect is increased by coppicing. In depressions in the plateau and in some of the smaller valleys the Oak Forests descend to far below their normal level—even to 1,200 or 1,500 feet above sea-level. The forests of some of even the major valleys are more simply considered as modifications of the Oak Forest rather than normal low-level forests. For example, around Namtu (Rainfall about 52″, 1,500 to 3,000 feet) the commonest trees include such denizens of the Oak Forests as *Quercus griffithii, Q. lindliana, Q. fenestrata, Q. spicata, Castanopsis argyrophylla, C. tribuloides, Acrocarpus fraxinifolius* (yetama), *Anthocephalus cadamba* (mau), *Sarcosperma arboreum* (ondon), *Callicarpa* sp., together with such forms of the lowland forests as *Terminalia tomentosa* (taukkyan, abundant) *T. belerica, T. pyrifolia, Dalbergia oliveri, D. cultrata, Schleichera trijuga, Bombax insigne, B. malabaricum* and many others.[1]

In the north of Burma (Patkoi Hills) De (36) remarks, that the Oaks of the Patkoi Hills have clear boles up to 40 feet.

Many of the Oak Forests are very wet, dark and unhealthy; mosses, lichens and orchids are abundant. Where the forests are more open (east of Toungoo, Somra Tract etc.) tall grass and patches of bracken are characteristic, or patches of pure bamboo. In damp regions of Toungoo the creeping bamboo (*?Teinostachyum helferi*) occurs as undergrowth.

Normally pines occur at a higher level than the Oak Forests, but examples are by no means wanting of the association of pines *(Pinus khasya)* with the oak forests as near Se-eng. Amongst the herbaceous plants forming the ground vegetation are many familiar English genera such as Jasmine, Clematis and Ivy; as well as Dog-violets, Bedstraws, Sundew, etc. together with tropical forms like Begonia, Gardenia, Hydrangea, Selaginella etc.

Several interesting cases occur of transitional stages between Dry Teak Forest or Indaing and Oak Forests (Plate V). In parts of the Upper Chindwin true Indaing (on poor soils) ceases at about 2,300 or 2,400 and passes into a mixed forest in which large in *(Dipterocarpus tuberculatus)*, ingyin *(Pentacme suavis)* and thitya *(Shorea obtusa)* form an upper story with oaks forming a lower story. The Dry Teak Forest, on better soil, persists there to a higher level. The occasional presence of certain

[1]The writer is indebted to Mr. A. R. Overlander for a list of the local trees of Namtu.

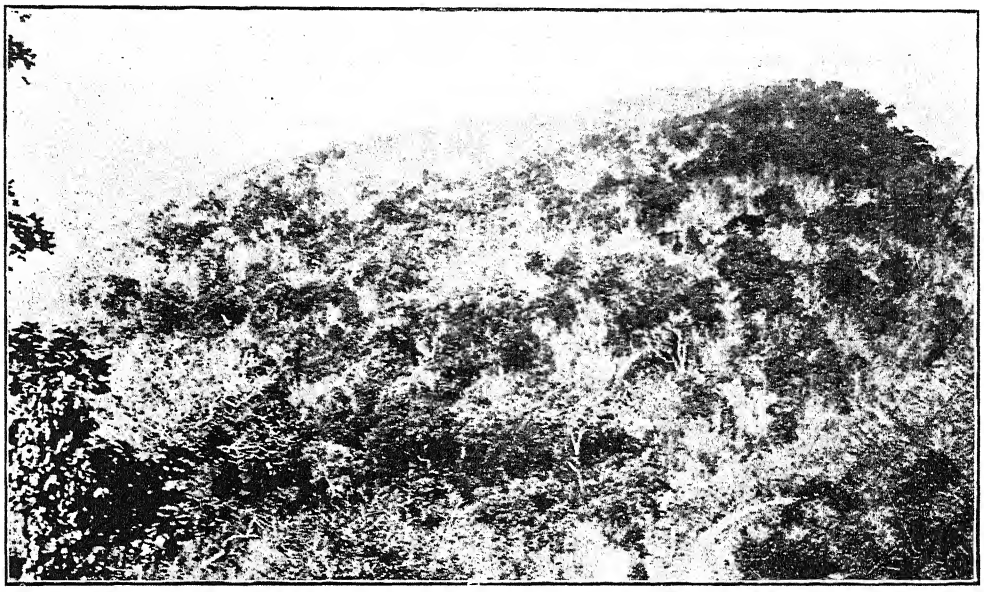


Fig. 1. Ml. Oak Forest. General view showing the open character (with grass blanks) of the Oak Forests of the Arakan Yoma. Near Naunggyo, 42nd mile Prome to Taungup Telegraph Line. Rainfall: probably 80—100″. Geology: Indurated shales and Sandstones, (Eocene). Season: late April (1924). Elevation: about 3,000′.
Photo: L. Dudley Stamp.

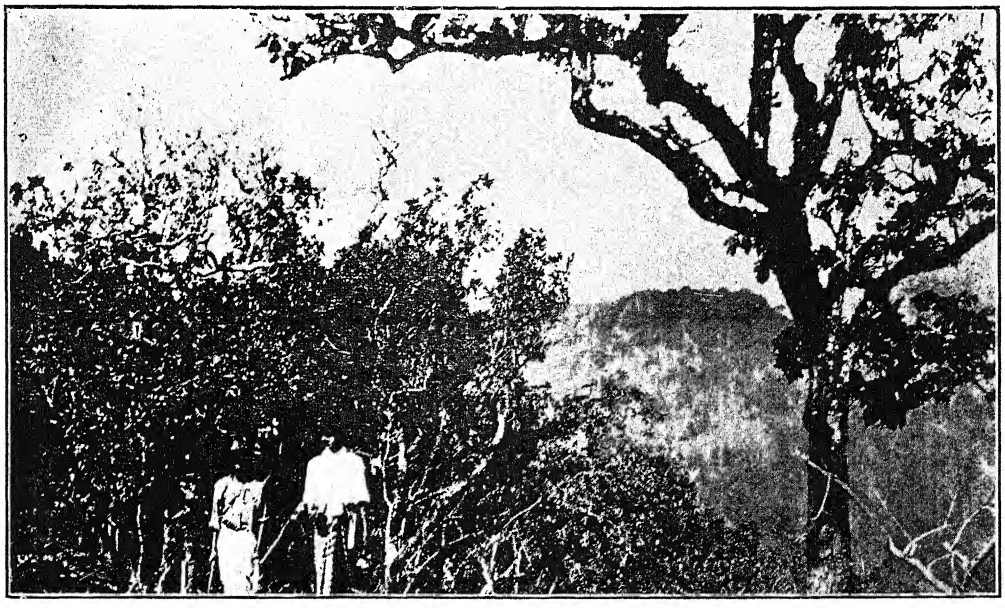


Fig. 2. Ml. Oak Forest. Taken near Fig. 1. Naunggyo is just east of the Arakan Yoma crest but still suffers the major part of the force of the S. W. Monsoon and a heavy rainfall. Notice the gnarled and stunted trees (due to soil and wind) wreathed in mosses, lichens (due to rainfall). Season: late April (1924).
Photo: L. Dudley Stamp.

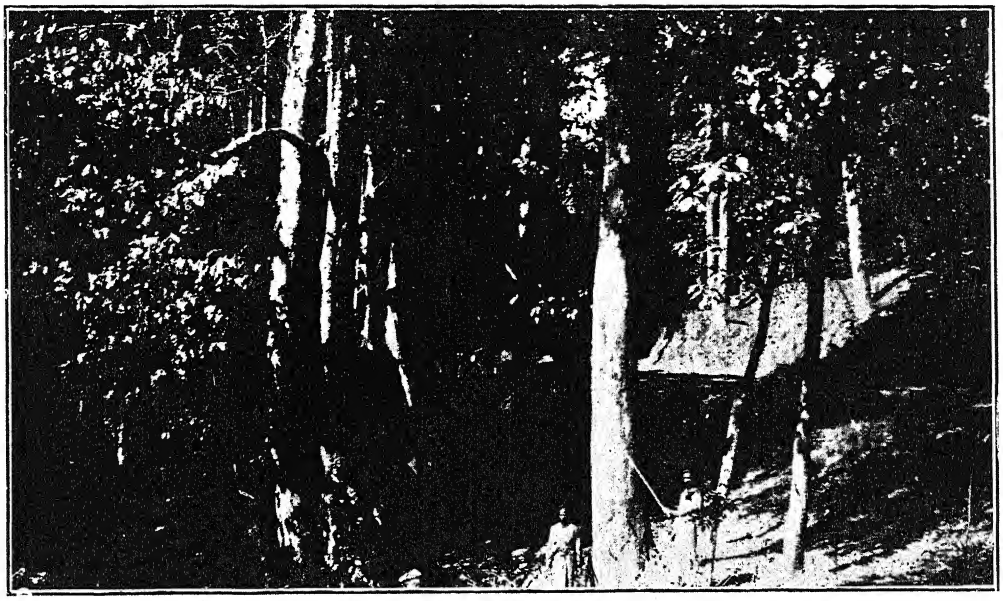


Fig. 1. Ml. Oak Forest. Near Nyaunggyo, 39th mile Prome to Taungup Telegraph Line. Effect of aspect, fine oaks growing near small permanent stream protected from the force of the S. W. Monsoon. Season: late April (1924). Photo: L. Dudley Stamp.

Fig. 2. Ml. Oak Forest. Near Nahsy, Namyao to Namtu Line. A normal type of Oak Forest from the Shan Plateau. Rainfall: about 60″. Geology: Soft ferruginous shales with limestone bands (Namyau Beds, Jurassic). Season: 20th May, 1924. Elevation: c2500′. Photo: L. Dudley Stamp.

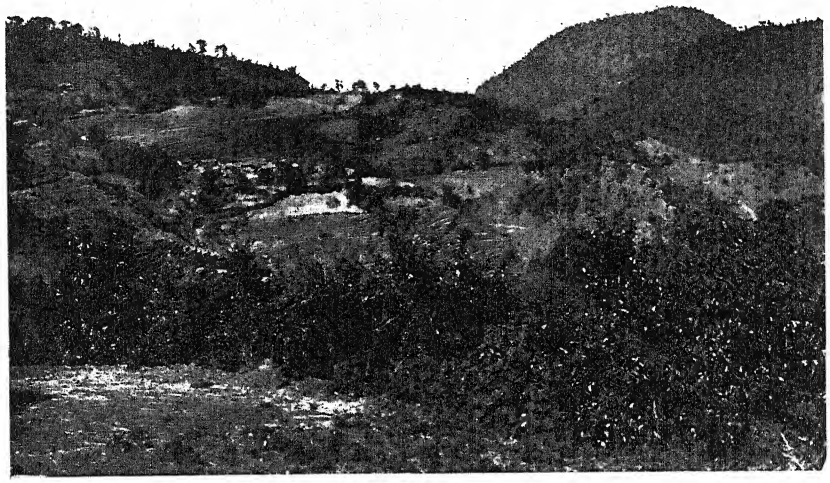


Fig. 1. M1. Scrub Oak Forest. Below La-meng, Salween Valley, Lung-ling—Shih-tien Route). Geology: Devono-Carboniferous Limestone. Elevation: about 2,500. Photo: J. Coggin Brown.

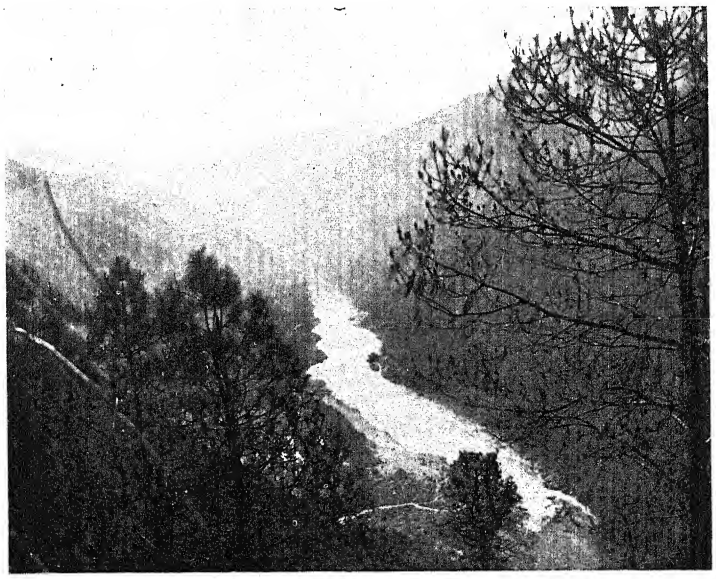


Fig. 2. M2. Pine Forest. View along the Mekong valley, North of Shun-ning Fu, Yunnan. Geology: Gneiss. Elevation: about 4000′. Photo: J. Coggin Brown.

species more characteristic of the Wet Evergreen Forests of Tenasserim in Oak Forests is a point to be noted; doubtless they are attracted by the moist surroundings and not deterred by the elevation.

From North-Eastern Burma Kingdon Ward describes what may be a variety of the Oak Forest—from higher levels. It consists of small oaks, rhododendrons, Bucklandia, Magnolia with numerous clumps of bamboo. The trees nearly all branch near the ground, sending up a great number of twisted and bent stems which interlace above. Clean straight trees are rarely met with.

HABITAT. Generally from 3,000 to 5,000 feet but may occur as low as 2,000. All the land of this height in Burma receives a sufficient rainfall and the lower limit of rainfall necessary is not known.

DISTRIBUTION. Probably over very large areas except where it has been ousted by grassland types or where light soils and higher elevation favour pines. In the extreme north-east the mixed forest seems to be rather different.

Undoubtedly these Oak Forests and Temperate Forests are capable of much sub-division but the data available are insufficient. Kurz's " Damp Hill Forests " seem to be a transition stage to the Evergreen Dipterocarp Forest.

M2 The Pine Forests (***Kurz: Pine Forests.***) Plate IV fig. 2 and Plate VI.

DESCRIPTION. Occasionally pines have been recorded in Burma as low as 700 feet (*Pinus merkusii* in Tenasserim and *P. khasya* on light sands in the Chindwin—Shwebo Hills at 1,000 feet), but normally the Pine Forests do not occur much below 4,000 feet. The principal species is *Pinus khasya.* The Pine Forests are much more sporadic in their distribution than the Oak Forests and cover a very much smaller area. Doubtless the distribution is largely controlled by soil; a light soil being desirable or necessary. The pines are described as reaching a very great size —even a 12 foot girth—at an elevation of 8,000 feet on the schists of the Kanpetlet ridge. Plate IV fig. 2 is about 75 miles outside the Burmese frontier, but illustrates the type.

HABITAT. A light soil at elevations of 3,000 to? 9,000 feet. In the north-east, Kingdon Ward (43, p. 88) refers to the " last of the silver firs " at about 11,000 feet.

DISTRIBUTION. On the higher ridges of the Arakan Yomas either on the sandy hills of such ranges of the Ponnyadaungs (and in the Upper Chindwin) or on schists as around Kanpetlet. The well known patches (such as at Kalaw) on the Shan Plateau seem to occur on sandy beds.

M3 Rhododendron Forest.

DESCRIPTION. This is probably the highest vegetation zone met with in Burma. Kingdon Ward gives many short descriptions of the Rhododendron Forests of the North-east. He says (p. 85) "Up to a certain point the rhododendrons grow bigger as one ascends the mountains, the biggest tree rhododendrons occurring at inter-

mediate altitudes, say 7,000 to 9,000 feet. Thence they rapidly decrease in size, till at 12,000 to 13,000 feet on the North-East Frontier and 14,000 to 16,000 feet on the Yun-nan ranges, they grow like heather in the Scotch Highlands. The smallest alpine species are considerably smaller than the bushes and small trees of low altitudes." Kingdon Ward gives a list of no less than 33 species (including indetermined) of *Rhododendron.* Silver firs are very frequently scattered through the Rhododendron forest and " thick bamboo grass from six to twelve feet high." At highest levels a multitude of alpine plants such as *Primula* becomes abundant and dwarf shrubs as juniper, willow and cherry are mentioned.

Describing a more typical Rhododendron Forest at lower levels, Kingdon Ward notes the smooth trunked trees with plank buttresses, the large conifers overtopping all other trees, whilst the " hideous ropes and ribands of crumpled wood, disfigured with loathsome looking warts, lie coiled like snakes in the gloom, and shouldering their way rudely through the dense foliage, burst into flower far overhead " Moss and ferns are abundant, orchids are numerous and the undergrowth is rank.

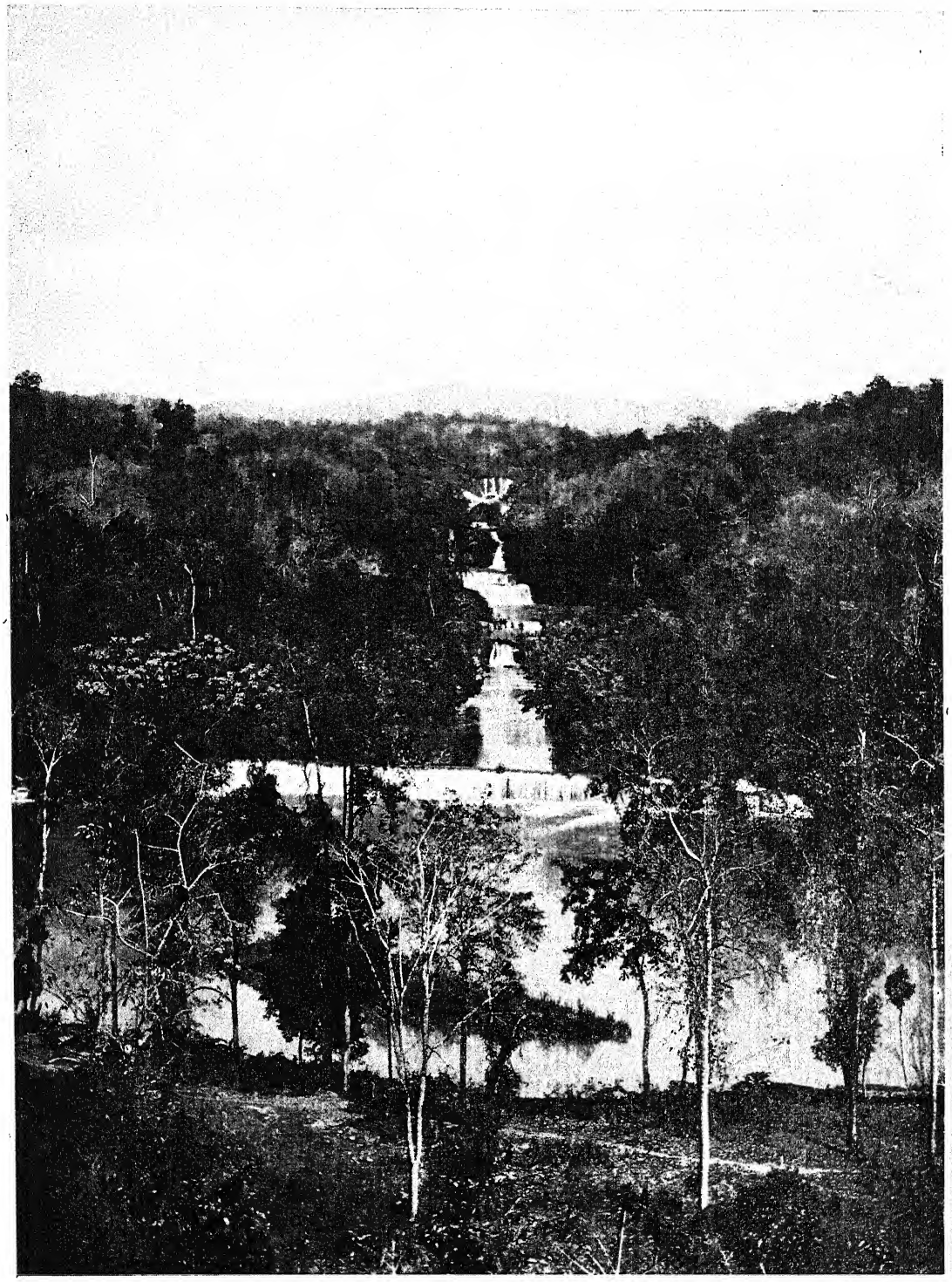
On the Arakan Yomas, Rhododendron Forest probably covers considerable areas; it is just touched at 5,000 feet in the Kyaw and Yawdwin Working Circles (10) (at the head of the Kyaw Chaung) and is said to prevail on the Mount Victoria ridge, above the Pine-Forest.

M4 Bracken Brake.

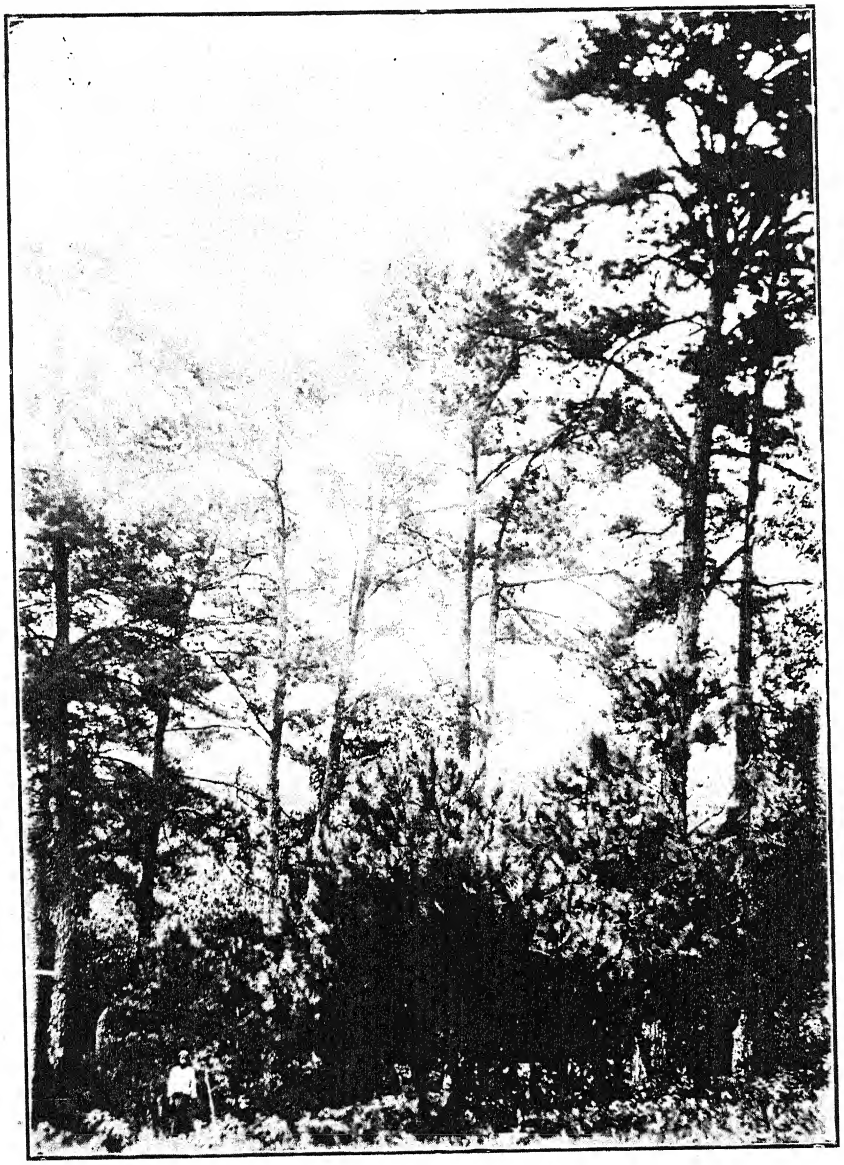
DESCRIPTION. Hill sides in the Shan States are often clothed with bracken, examples being described from as far south as the latitude of Toungoo, but further north the type would seem to be very common. The " bracken-covered " hillsides around Hpimaw and near the Yunnan frontier (east of Myitkyina) are repeatedly referred to Kingdon Ward (43). He notes that the northern slopes of the hills are usually forested [probably because they are colder and have not been cleared for cultivation] whereas the southern slopes are bracken covered. The bracken is often 7 feet high. A common plant is a meadow-rue *(Thalictrum sp.)* Some observers believe that the Bracken Brake is scarcely a natural formation but is the result of " taungya " cultivation. Rae and Tottenham and later Rorie (32) have described the great bracken covered areas of the Bhamo-Kachin Hills, stretching right over the Chinese frontier. Rorie divides this vaste area of Bracken Brake into three divisions:—(a) Lower Zone, below 3,000 feet, with a few trees and bamboo (wapyugyi, *Dendrocalamus membranaceus*). The trees are yetama *(Cedrela febrifuga)*, bambwe *(Careya arborea)*, *Terminalia belerica*, *Cassia fistula*, *Cedrela multijuga*, etc. (b) Upper Zone above 3,000 feet with a few trees of *Schima wallichii*, *Betula alnoides*, *Eurya acuminata*, *Macaranga denticulata*, oaks, and chestnuts and, above 4,500 feet *Alnus nepalensis.* (c) Bracken with no trees. The Forest Department is successfully planting much of the Bracken area with *Alnus nepalensis*, while the English alder is being tried in frost hollows.

M5 Mountain Bamboo Brake. (See also L4).

DESCRIPTION. On the hilly regions of the North-eastern Frontier, Kingdon Ward describes a type of bamboo-brake, wreathed in mosses, so thick that one cannot see more than a few yards into it. It occurs on hill sides, in the midst of the region



L6-7—M1. Teak-Oak Forests, Transitional Types. View of the Man-Sang Falls, Namyau River, Shan States before the utilization of the water-power. Taken in the dry season, so that the species of the Teak Forests appear leafless whilst the denizens of the Oak Forests remain in leaf. Geology: Devono-Carboniferous Limestone. Elevation: 1600′ to 2300′. Photo: T. H. D. La Touche.



M2. Pine Forest. *Pinus khasya.* Kalaw, Shan States. Geology: Red Sandstones (?). Elevation c.4300′. Season: July (1924). Photo: Colyer, Kalaw.

Fig. 1. L1. Evergreen Dipterocarp Forest. Hermingyi, Tavoy. Partly cleared for the mining camp and so showing the rather characteristic glistening white trunks unbranched to a great height and the dense canopy. Rainfall: c200″. Geology: Contorted slates (phyllites) of the Mergui series. Photo: M. Inui Studio, Tavoy.

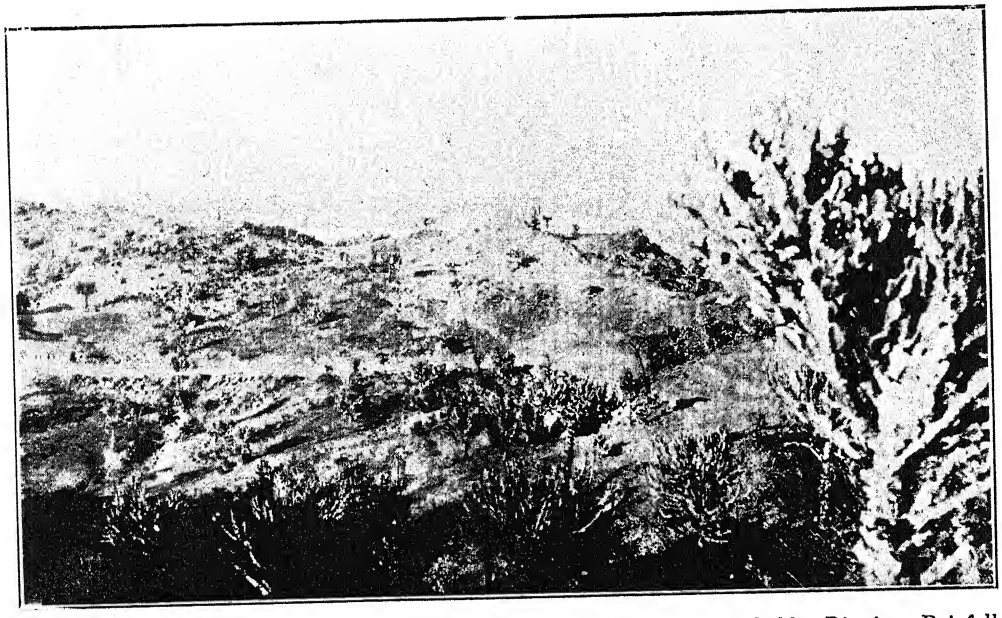
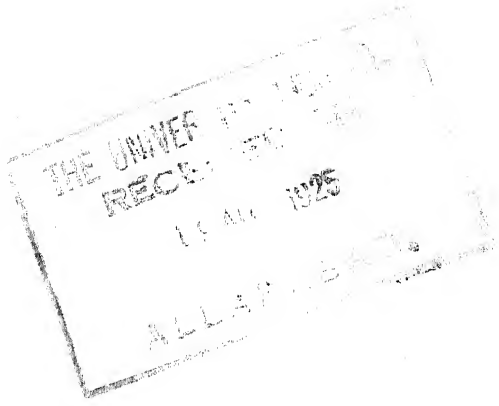


Fig. 2. L17. Euphorbia Semi-Desert. *Euphorbia antiquarum*. Lanywa, Pakokku District. Rainfall: c20″. Geology: Peguan gypsiferous clays and sandstones. Season: Early May (1924). Photo: L.D.S.
These two photos show the extreme types of vegetation produced in Burma by difference of rainfall.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of the Oak Forests. Often the Bamboo forms a dense dark forest of considerable height. It also occurs at great heights. Ward refers to the " odious growth of dwarf bamboo which is the curse of these granitic ranges" (east of Fort Hertz) at heights up to 11,000 feet. "It practically replaces the alpine herbaceous flora found further east and the only thing which can compete with it is the Rhododendron carpet ".

M6 Mountain Grassland.

DESCRIPTION. Grassland, apparently a climax community, covers large areas of the Shan Plateau, and is found on level ridge tops in the Arakan Yomas, the Chin-hills and on hill slopes of North-eastern Burma. Doubtless several types are to be distinguished but the writer knows of no available data. However, the open, breezy rolling downs of the Shan Plateau are worthy of special note. The flora is almost European in aspect including such familiar plants as wild roses, honeysuckle, numerous labiates, convolvulates, willow-herbs, anemone, milkwort, clematis, violet and St. Johns's wort. The flora has been described by Collett and Hemsley (35). Here the edaphic control of the fissured Plateau Limestone seems to play an important part. In other localities the grassland is due to human agency. The hills round the Bawdwin Mines (2,000-4,000) are grass covered, all the trees having been used by the old Chinese miners and natural regeneration prevented by the poisonous gases produced in smelting. Now (1924), however, trees are re-appearing, the main enemy of regeneration having been removed.

L1 Evergreen Dipterocarp Forests. (*Wet Dipterocarp Forests; Tropical Rain Forests; Kurz: Tropical Forests*). Plate VII Fig. 1.

DESCRIPTION. This is really the only type of forest in Burma which approaches one's preconceived ideas of a tropical forest. The present lack of detailed knowledge necessitates the consideration together of the Wet Dipterocarp Forests of Tenasserim and those of the southern parts of the Pegu Yomas but the former are to be regarded as more typical, occurring as they do nearer the equatorial rain belt. They are lofty, dense evergreen forests, characterized by an immense number of species of trees, nearly all of which yield very hard timbers. Of the two dozen better known species present in Tenasserim no less than half belong to the Dipterocarpaceae. The following are the more important:—kanyin (including the varieties known as kanyin-byu, kanyin-byan and kanyin-ni—*Dipterocarpus alatus, D. griffithii, D. laevis* and *D. turbinatus)*, kaban *(Shorea spp.)* kadut *(Anisoptera* sp.*?)*, thingan *(Hopea odorata)*, *Hopea* spp., kaunghmu *(Parashorea stellata)* (all the preceding are Dipterocarps); *Lagerstroemia* spp., anan *(Fagraea fragrans)*; kanzaw *(Bassia longifolia)* and gangaw *(Mesua ferrea)*. The trees in this list are mainly ones which have attracted attention on account of their timber, but species are so many that it is difficult to frame any representative list. Consociations are, strictly speaking, almost absent, the species being intimately mixed. Many of the species, such as kadut and kaunghmu in the above list, form magnificent trees 15 feet in girth at five feet from the ground and 100 feet of clear bole before the first branch. Little has been written of the details of these forests. The canopy is extremely dense. Epiphytes are numerous especially filmy ferns, mosses and fungi and some orchids. Ground vegetation in typical cases may be almost absent; elsewhere a carpet of *Selaginella* and ferns may occur.

An excellent description of typical Equatorial Rain Forests may be found in Hardy's "Geography of Plants" or Schimper's "Plant Geography", but one is left with a strong doubt whether the gloomy, vault like type, where sunlight never penetrates the lifeless floor, is really typical. It certainly does not seem to be in Burma, Malay Peninsula or Borneo.

In the Pegu Yoma Forests the most typical trees include kanyin *(Dipterocarpus alatus* and *D. turbinatus)*, thingan *(Hopea odorata)*, kaunghmu *(Parashorea stellata* Kurz), pyinma and leza *(Lagerstroemia* spp.), thitka *(Pentace birmanica)*, thetyin *(Croton oblongifolius)*, inbo *(Dipterocarpus sp.)*, thin-kadu *(Anisoptera glabra)*, thayet-san *(Swintonia)*, myauklok *(Artocarpus lakoocha)* and *Baccaurea sapida.* The undergrowth is often a tangle of canes *(Calamus spp.)* and creeping bamboo (watha-but, *Teinostachyum helferi)* and palms. This undergrowth may become predominent and in valleys and along stream occurs the Cane Brake often replaces the forest.

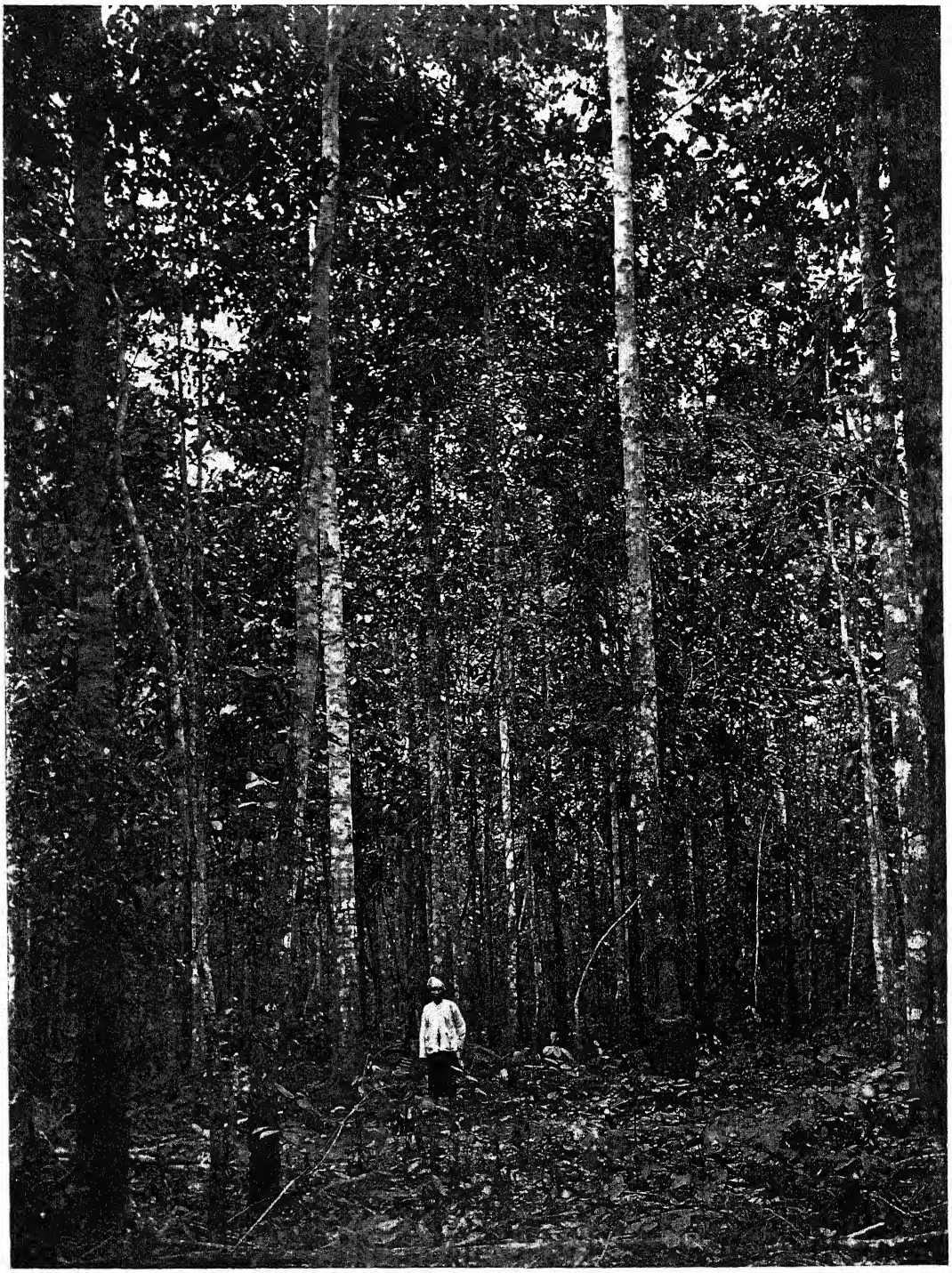
In the patches of Evergreen Forest in Arakan kanyin and thinban *(Buchanania lancifolia)* are the dominant species.

HABITAT. These evergreen forests occur in rainfalls of from 80 inches upwards, as in damper situations of the southern end of the Pegu Yomas, but are more typically developed where the rainfall is between 150 and 200 inches in Tenasserim. Mr. J. C. Hopwood (40) has pointed out that a number of species seem to prefer low ground (thingan, *Hopea odorata* and *Lagerstroemia)* but others occur at moderate elevations of from 1,500 to 2,000 feet. *Lagerstroemia* is typically a riverine genus.

DISTRIBUTION. Wet Dipterocarp Forests cover very large areas of South Tenasserim but are still very imperfectly known. Similar forests occur over large areas in the Malay Peninsula, with a rainfall of about 100 inches. The typical Dipterocarp forest occurs up to 2,000 feet above which conifers become important and Dipterocarps disappear. In the lowland forest Dipterocarps (especially *Dipterocarpus, Vatica, Hopea* and *Shorea)* form half the total stock. More than 100 species are known. The Evergreen Forests of the Pegu Yomas have been often described. In the south they occur over large areas but further north are found near stream-courses. Descriptions exist of these in the Working Plans for the Saing Circle, N. Toungoo, Tharrawaddy, Nyaunglebin Circle, N. & S. Zamayi, Rangoon Hills Forests and others (2, 3, 6, 13, 23, 24, 25, 26). The northerly limit in the Pegu Yomas as narrow strips in some valleys seems to be about the E. Yoma Forests of the Thayetmyo Division (20.) The Dipterocarp Forests of the Lushai Hills, described very briefly by Gage (37) seem similar, but elevation—the forests are found in the valleys from 2,000 to 3,500 feet above sea-level—is marked by such trees as *Schima Wallichii.* Evergreen Dipterocarp Forests occupy most of the Kyeintali and Sitsayan Reserves in Bassein, behind an eastern fringe of Pyinkado Forest.

L2 Wet Evergreen Forests, Northern-Type. Plates VIII and X.

DESCRIPTION. Wet Evergreen Forests reappear in Northern Burma where the rainfall again exceeds 80 inches. It should be noticed that these forests occur mainly north of the Tropic of Cancer and so are actually in the Temperate Zone. They are.



L2. Evergreen Dipterocarp Forest, Northern Type. Group of *Shorea assamica*. Mezabya Reserve, near Hmattaing, Katha Division. Rainfall: probably about 30".

however, to be considered as Tropical and not as Temperate Forests. These northern forests are still very imperfectly known and observers are by no means unanimous in their general statements. The writer has not personally visited the forests and he is much indebted to Messrs. A. H. M. Barrington, H. R. Blanford, C. G. E. Dawkins and others for much of the information contained below. One of the chief distinctions between the Northern Evergreen Forests and the Southern type is the relative paucity or absence of Dipterocarps and the Forests can no longer be described as Dipterocarp Forests. *Anisoptera glabra, Parashorea stellata* and *Swintonia floribunda* all of which are characteristic Pegu Yoma species, no longer appear. Their place is taken locally by *Shorea assamica.* This species is seen to perfection on the slopes of Maingthon Taung between 3,000 and 5,000 feet. Elsewhere it is much less common. Kanyin is often common as in Myitkyina and Katha; it is probably *Dipterocarpus laevis. D. turbinatus* also occurs but not *D. alatus.* There is not much difference in these Northern Forests between the plains Forests and the hills Forests. That is to say types LI and L8 of the south have largely merged; in some areas, however, deciduous strips tend to occur along the foot of the hills, in valley mouths and on uncleared flats. Of the vegetation of the Hkamti Plain south of Putao, Kingdon Ward says (p. 256) " the forest is evergreen in spite of chill winter nights " and he refers to " strapping Dipterocarp trees with glistening white trunks bearing heavy crowns of foliage " in the " dark green forest."

In general there seems a strong tendency for trees of the genera *Dysoxylum, Michelia, Cedrela* and *Chukrasia* to usurp the place of Dipterocarps and the latter are often completely absent. Another characteristic feature is the bamboo, wabo myetsandye*(Dendrocalamus hamiltonii).* Many canes and tree ferns also occur.

Taking now certain special areas, De (36) has stated that the forests north of the Hukawng Valley do not differ greatly from those on the other (northern) side of the Patkoi Hills, which there form the divide between Burma and Assam. From north of the Patkoi Hills he notes gangaw *(Mesua ferrea), Teminalia myriocarpa, Shorea assamica* and *Dipterocarpus pilosus* together with *Quercus semiserratus.* The association of oaks and other species of the temperate or mountain forests of Upper Burma with denizens of the Wet Evergreen forests is also to be noted in Katha and Myitkyina. Dawkins notes there a " gigantic tree flora " with *Dipt. laevis, Dysoxylum binectariferum, Cedrela* spp., *Morus laevigatus, Quercus lamellosa, Q.* spp., *Castanopsis* spp., *Acrocarpus fraxinifolius, Mesua ferrea* and *Eugenia* spp. " In places teak occurs in the lower evergreen, it is usually large, rather shapeless and overwhelmed by climbers, showing no desire to reproduce itself " (Dawkins). It is itself almost an evergreen. Where bordering on the deciduous strips, deciduous trees such as *Gmelina arborea, Tetrameles nudiflora, Protium serratum, Chukrasia, Adina cordifolia* and *Lagerstroemia flos-reginae* appear but *Lag. villosa* and pyinkado are absent.

In the Mosit Reserve of the Bhamo Division the evergreen forest consists of *Dipterocarpus turbinatus, Mangifera indica, Eugenia* sp., *Wallichia distincta* together with *Bambusa pallicea.* Small strips of evergreen occur in the Indaung Circle, Mogok and include *Mangifera, Artocarpus lakoocha, Alstonia scholaris* and *Mitrephora maingayi* (A. P. Davis). The Kanyin-Pyinma-Teak Forests of the Maingtha, Kun-

chaung and Nanne Reserves (Mogok) are more akin to the Pyinkado Forests or even the Moist Teak Forests of the south.

HABITAT. Evergreen forest reappears in the northern part of Burma where the rainfall reaches over 80 inches. "The reason for the prevalence of evergreen even on low ground in the North is fairly obviously the comparative shortness and dampness of the hot season. The winters are chilly and prolonged, showers occur fairly frequently and damp mists prevail. There is hardly any real dry hot weather till after March and even then showery intervals break it" (Dawkins). There is a close relationship with several types of Mountain Forest.

DISTRIBUTION. On both low ground and hilly ground in Northern Burma only separated from similar Forests in Assam by the mountain Oak Forests of the Patkoi Hills and other divides.

L3 Mixed Cane Brake. (*Calamus-Pseudostachyum Association*)

Plate IX.

DESCRIPTION. It is found that small valleys and stream-courses in the midst of the Wet Evergreen Forests are frequently filled by an impenetrable thicket of canes, palms and bamboos (especially creeping bamboo). The most typical species are:—*Calamus spp.* (canes)*, palms such as *Calamus arborescens*, *Licuala peltata* and yingan *(Zalacca wallichiana)*, as well as the creeping bamboo, wathabok *(Teinostachyum (?) helferi)* together with some kyathaung *(Bambusa polymorpha* Munro). Where extensive areas of this type of vegetation occur, a few kanyin trees are found as standards. Plate IX shows a view amongst Cane Brake in Assam, but the Burmese type is very similar.

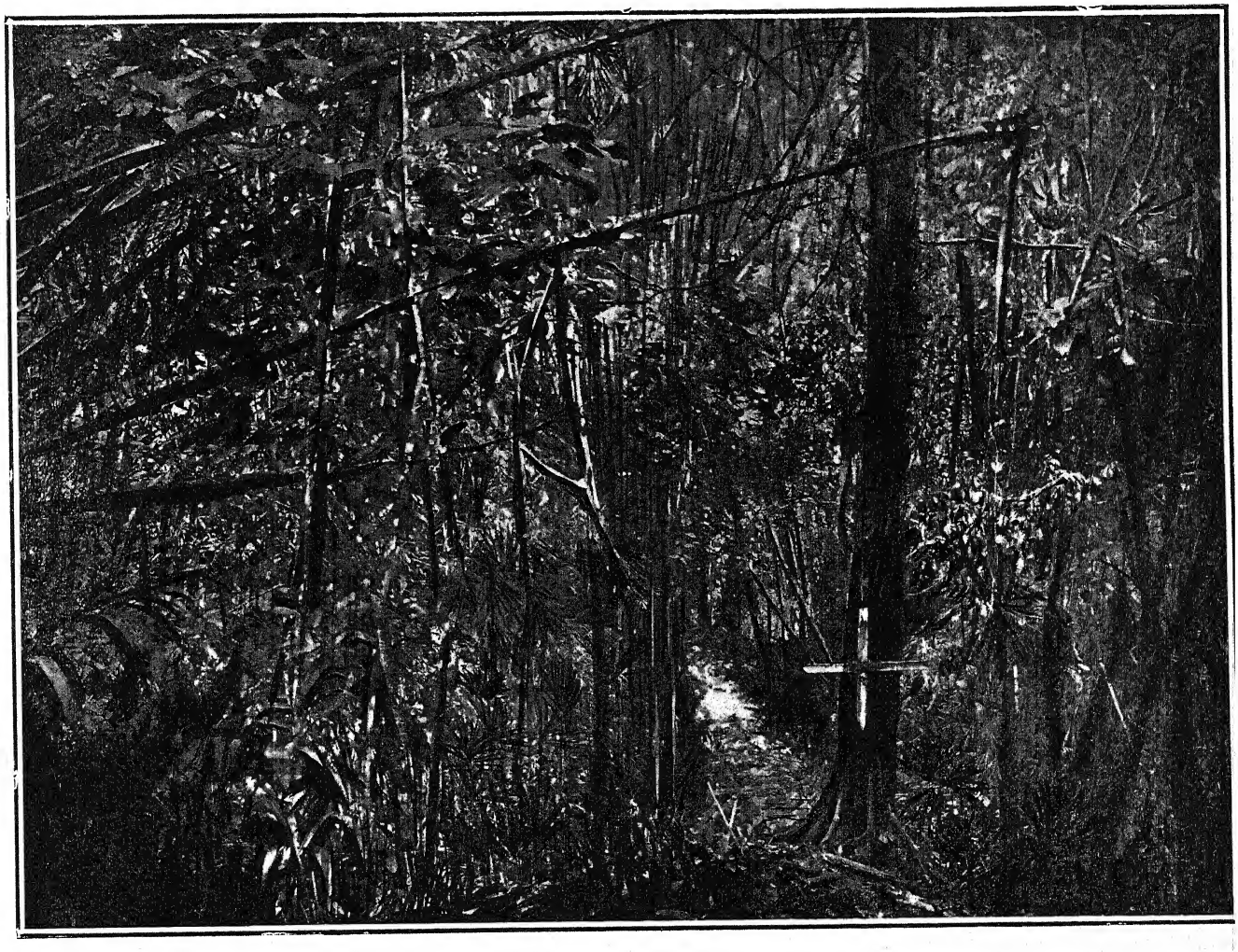
HABITAT. In the damper parts (river valleys, etc.) of areas with a rainfall of 80 inches and upwards, especially over 100.

DISTRIBUTION. Examples are described from most of the areas of Wet Dipterocarp Forests, as from the Rangoon Hills, S. Zamayi, Laungtu Circle, E. Yoma, Satsuwa, Tindaw, Saing Circle and most of the other Pegu Yoma Reserves.

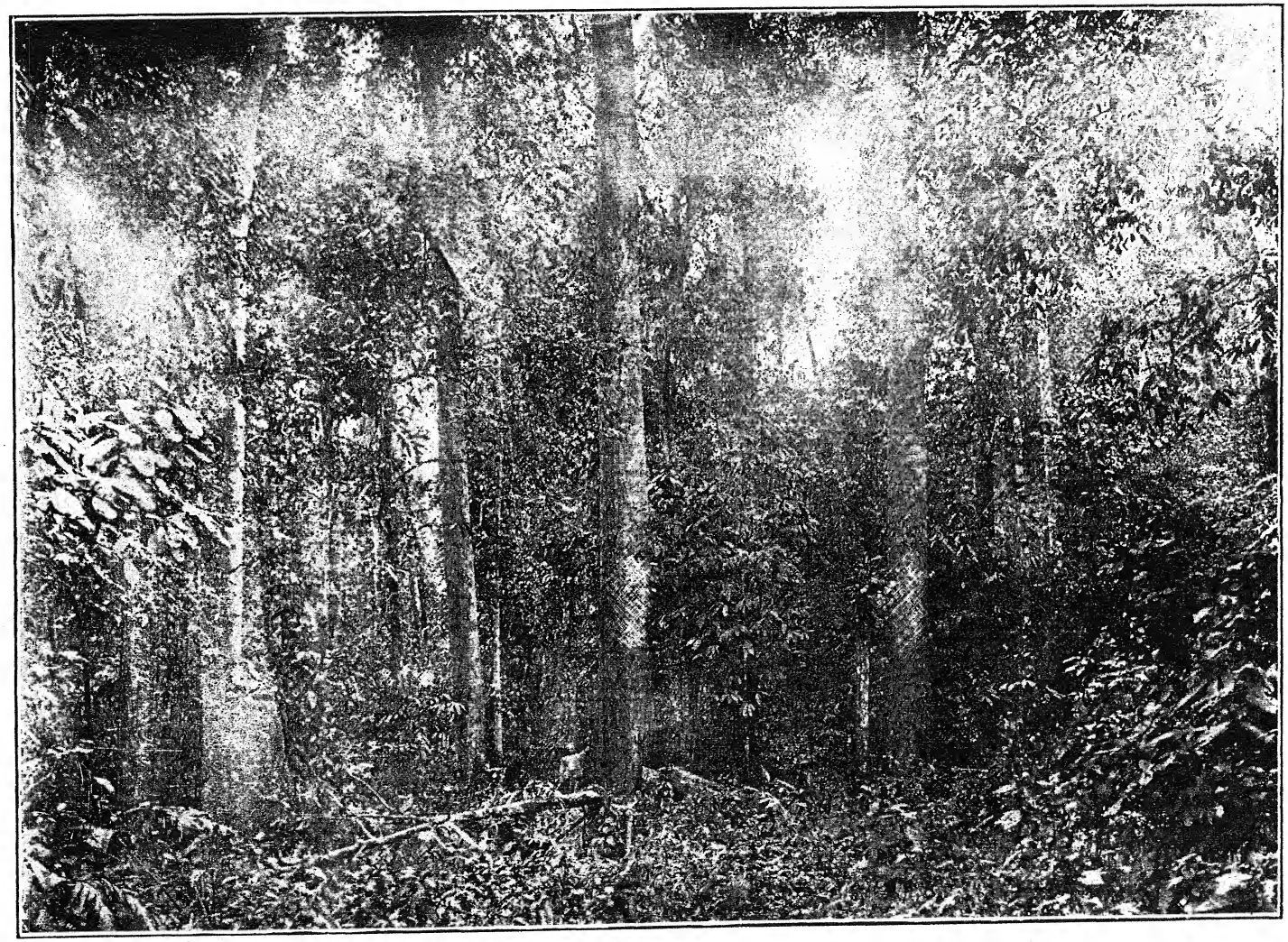
L4 Bamboo Brakes (*Kurz: Bamboo Jungles.*)

DESCRIPTION. Bamboo brakes, differing widely in character and aspect cover enormous areas in Burma. The spread of bamboo at the expense of forest has undoubtedly been greatly helped by the hand of man. Land which has been cleared of forest, temporarily cultivated and then deserted is often taken possession of by bamboo. Many forest officers are inclined to regard all the areas covered by bamboo brake as having been originally forested but this is an important assumption and may not be borne out by further study. As A. H. M. Barrington (3) says "natural forest in Burma is usually rich in bamboo undergrowth and poor in trees. The most extreme example I know is in the Lemru Valley of North Arakan where one may count, from one side of the valley, the trees growing on the opposite slope."

*The following species are commonly cut and used:—
C. erectus, Roxb, *C. guruba* Ham., *C. latifolius* Roxb., *C. longisetus*, Griff., *C. viminalis*, Wild and *Korthalsia luciniosa* Mart.



L3. Mixed Cane Brake along the Rajgarh Ali, an old Assamese highway, Assam. Rainfall: over 200″. Geology: Tertiary Sandstones (?). Photo: R. R. Simpson.



L2. Wet Evergreen Forest, Northern Type. Kanyin (*Dipterocarpus turbinatus*) Auktaw Reserve, Katha Division. Rainfall: c.80″. Photo: H. R. Blanford.

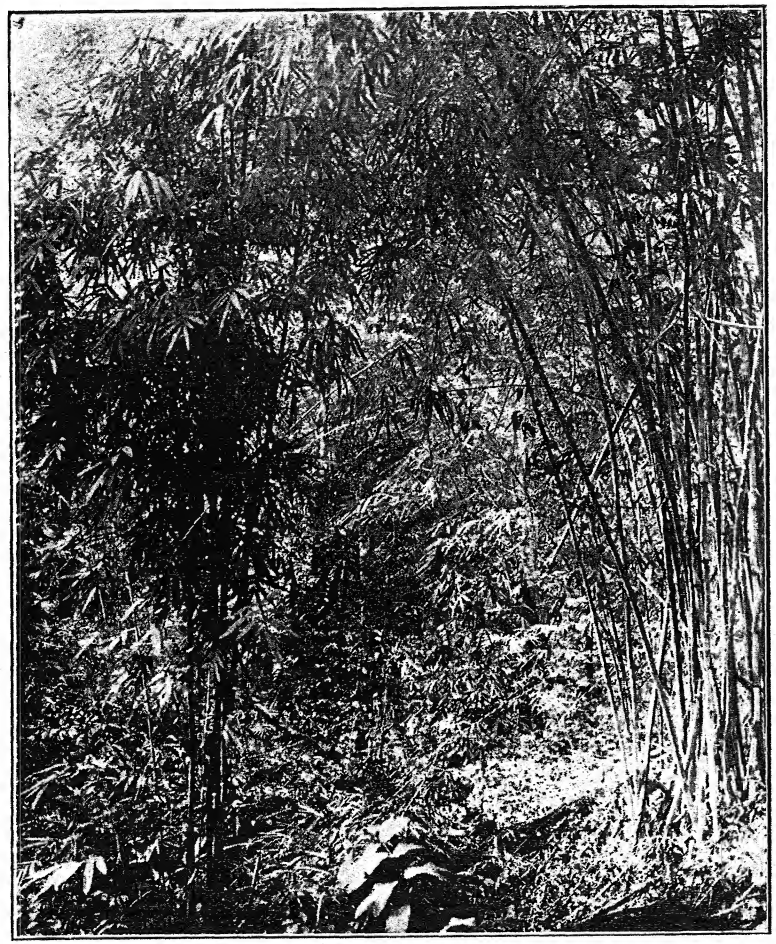


Fig. 1. L4b. Bamboo Brake (Wanwe) *Oxytenanthera albo-ciliata.* Myohla Reserve, Toungoo. Rainfall, about 65″. Geology: Probably coarse sandstones (Upper Peguan.)

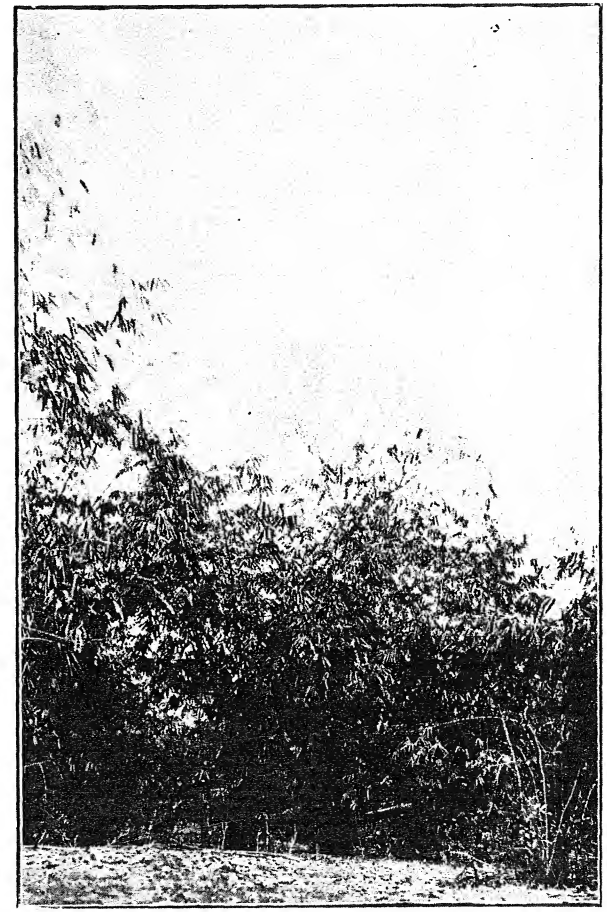
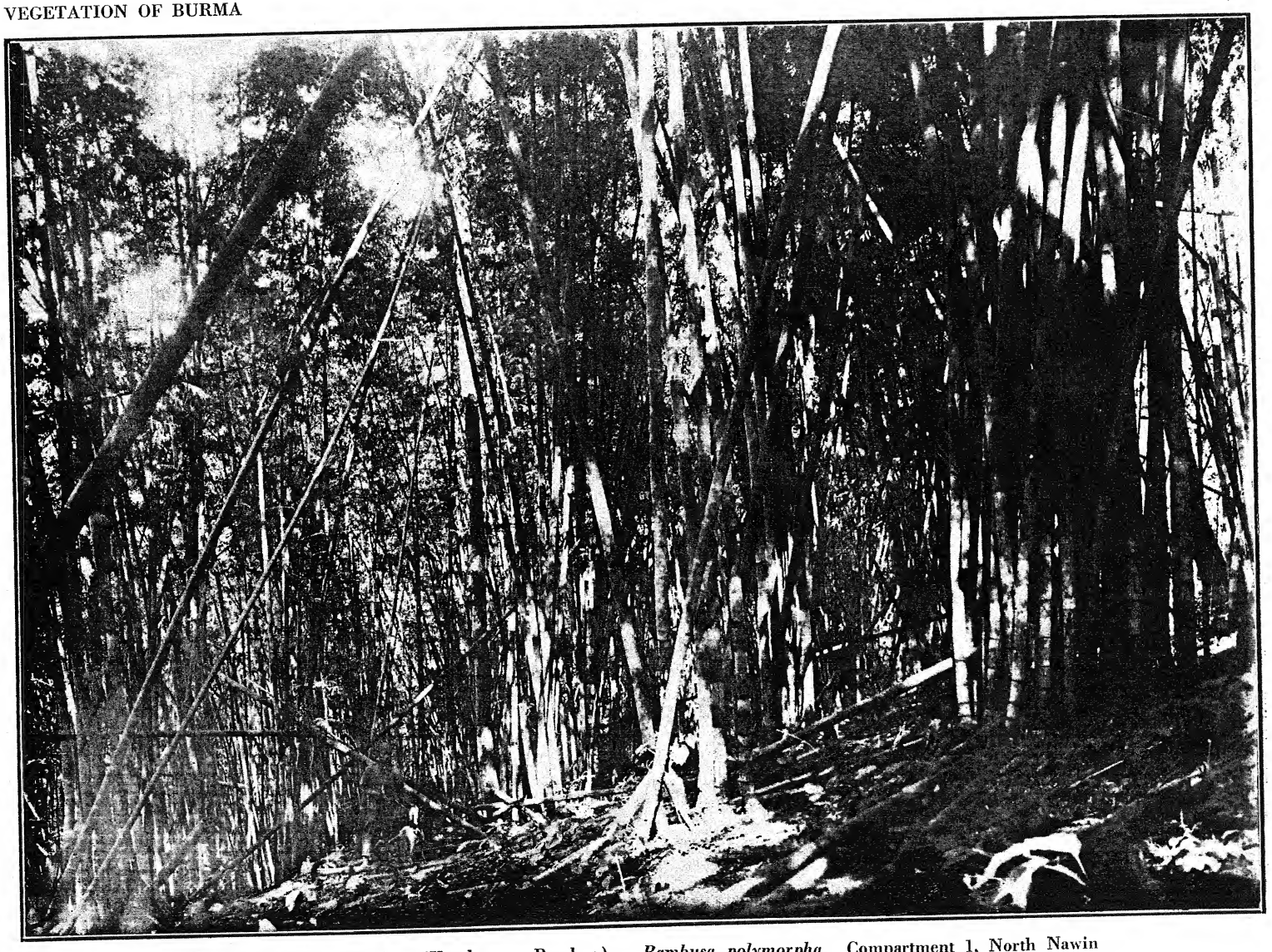
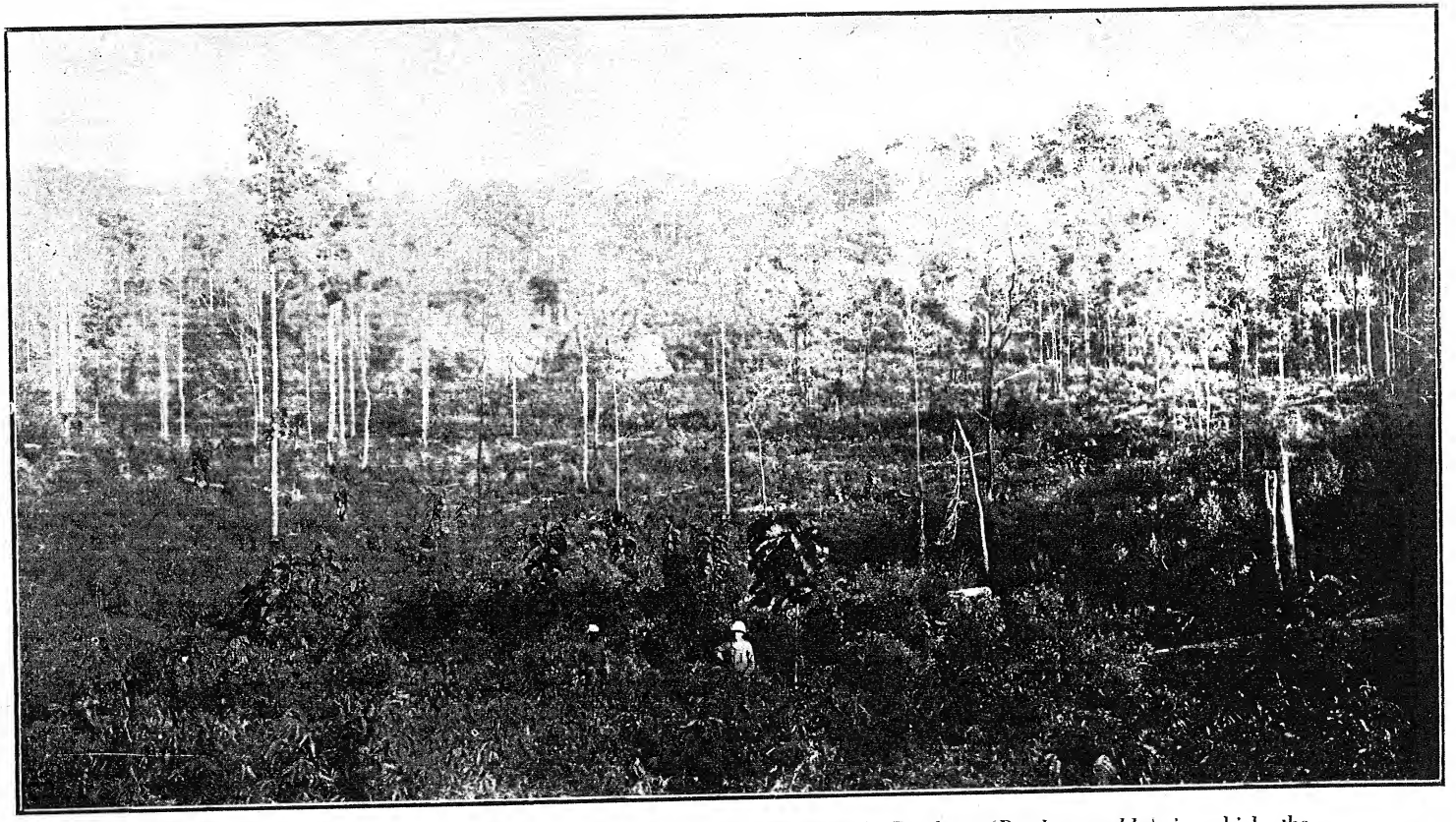


Fig. 2. L4b—L5-7. Bamboo Brake (Wanwe) in Dry Forest with Pyinkado *(Xylia dolabriformis*—in background*)* Rainfall: 140″. Geology: Alluvium over Late Tertiary. Season: March, 1924. Near Kyaukmadaung, Tavoy. Photo: L. Dudley Stamp.



L4c. Bamboo Brake (Kyathaung Bamboo). *Bambusa polymorpha.* Compartment 1, North Nawin Reserve near Nyaungwin, Prome Division. Rainfall: about 45″. Geology: Peguan Sandstones and shales. Photo: A. Rodger.



L4e. and L6. Forest of Teak (*Tectona grandis*) and Thaik Bamboo *(Bambusa tulda)* in which the bamboo has flowered and died. The foreground is now clothed with a dense growth of young bamboo, with scattered 1-year old shoots of Teak. The widely scattered trees show the poor character of the original forest. Singaung, Prome Division. Rainfall: about 45″. Geology: Peguan Beds, probably mainly shales. Season: Jan. 1916. Photo: A. Rodger.

Fig. 1. L4g. Bamboo (Myinwa) Brake. *Dendrocalamus strictus.* Rainfall: about 35″. Geology: Alluvial fan from hills. Season: 30th May 1924. Near Sedaw, Maymyo Line. Photo: L. Dudley Stamp.

Fig. 2. L4c. Bamboo (Kyathaung, *Bambusa polymorpha*) in Moist Teak Forest. Rainfall: about 70″. Geology: Peguan fine sandstones with bands of shale. Season: March 1924. 1 mile East of Ngalawa Bungalow, Tharrawaddy Division. Photo. L. Dudley Stamp.

Most types of forest from the Evergreen Dipterocarp to the Dry Deciduous or Semi-Indaing may be replaced by bamboo jungle and the dominant species are often the same as the dominant bamboos in the neighbouring forest. Good teak is often accompanied by kyathaung bamboo, and the presence of bamboo brake of kyathaung is very often indicative of conditions especially suitable for teak although not a single tree may actually be growing.

The bamboo brakes range from those which replace Evergreen Dipterocarp Forests and which may be closely akin to the mixed Cane Brakes just described to the very driest type characterised by myin *(Dendrocalamus strictus)*. The following are some of the more important types of Bamboo Brake:—

L4a—Kayinwa[1] Brake *(Melocanna bambusoides* Trin.*)* covers enormous areas in Arakan. Out of an area of 6,000 square miles investigated by Barrington in North Arakan more than 5,000 are covered by kayinwa with a few poor scattered trees such as zinbyun *(Dillenia pentagyna)*, bambwe *(Careya arborea)* and thabye *(Eugenia sp.)*. Kayin is a bamboo which sends up single stems from creeping roots and seems to be able to spread into, and destroy, high forest without the help of man. It ascends to high levels, and the writer noticed it spreading well over the Arakan Yoma divide into the Prome District at 3,000 feet.

L4b—Wanwe Brake *(Oxytenanthera albo-ciliata* Munro) occupies large areas in Tenasserim, especially on the badly drained late Tertiary and recent deposits filling up old lake basins. Its stems, bending over in all directions, form a very dense mass. Scattered trees noted included zinbyun, thingan *(Hopea odorata)* and pyinkado. The vegetation seems of a peculiarly dry type considering the heavy rainfall. Plate XI.

L4c—Kyathaungwa Brake *(Bambusa polymorpha* Munro*)* occupies large areas in the Pegu Yomas, replacing Pyinkado and Moist Teak Forests, just as the last two replace Evergreen Dipterocarp Forests. Some tinwa usually occurs too. Plate XII and Plate XIV, fig. 2.

L4d—Tinwa Brake *(Cephalostachyum pergracile* Munro*)* covers smaller areas than the last and in similar situations but on a soil drier physically or physiologically, and it is less susceptible to damage by fire than kyathaung.

L4e—Thaikwa Brake *(Bambusa tulda* Roxb.*)* tends to occur on poorer, more shaley soils than the last two. Plate XIII.

L4f—Wabomyetsan ye Brake (*Dendrocalamus hamiltonii* Nees and Arn.*)* is a characteristic vegetation of Upper Burma especially replacing Evergreen Forest. As in L4b the stems are nearly horizontal and cover large areas of ground.

[1] "Wa" (Burmese) is the comprehensive word for bamboo.

L4g—Myinwa Brake *(Dendrocalamus strictus* Nees*)* replaces the Dry Teak and many drier types of forest and occurs with a rainfall as low as 35 inches (Plate XIV fig 1.)

Many other types of Bamboo Brake might be separated and this classification extended. It will be noted that most of the bamboos are markedly gregarious and the bamboo brakes listed above tend to be very free from other species. It is well known that the more important bamboos flower at long intervals (30 to 70 years) over large areas at the same time. The parent plants die and the young seedlings spring up to form a dense carpet highly destructive to young tree seedlings (Plate XII.) The burning of the dead bamboo is often instrumental in the destruction of any remaining trees, especially where the latter are species of the Wet Evergreen Forests and cannot stand fire. This actually happened in the Ru valley of North Arakan.

L5 Pyinkado or Semi-Evergreen Forest. (*Xylia dolabriformis Forest.*)

DESCRIPTION. Pyinkado *(Xylia dolabriformis,* the Burma ironwood) is a tree which on the whole flourishes under a higher rainfall than teak. Pyinkado in its distribution may be said to be co-extensive with teak, but at the same time occurs over large areas from which teak is practically absent. In regions enjoying a rainfall of from 80 to 100 inches pyinkado tends to occur to the partial or total exclusion of teak. The Pyinkado Forests are, then, intermediate in character between the Wet Dipterocarp Forests and the Moist Teak Forests. Pyinkado is often dominant; a fairly constant associate is pyinma *(Lagerstroemia* sp.*)*; kanyin *(Dipterocarpus alatus* and *D. turbinatus)* occurs, but in fewer numbers. Other trees include myauk chaw *(Homalium tomentosum)*, yemane *(Gmelina arborea)*, gyo *(Schleichera trijuga)* and bambwe (*Careya arborea*). The predominant bamboos are kyathaung *(Bambusa polymorpha* Munro) and, less abundant, tin *(Cephalostachyum pergracile* Munro*)* but wapyu sometimes occurs *(Dendrocalamus membranaceus)*. The typical forests just described are from the southern end of the Pegu Yomas. Forests, semi-evergreen or evergreen, in which thinbon *(Buchanania lancifolia)* is dominant cover considerable areas in Arakan especially on detritus below steep slopes; poor kanyin and thingan also occur and this forest should probably be considered a variety of L1. True Pyinkado Forest does occur in Arakan in somewhat similar positions. In parts of Southern Arakan, Pyinkado Forest occurs on the foothills and in the valleys between them the hills being covered with Bamboo Brake or Evergreen Forest according to the soil. The forests on the eastern side of the Arakan Yomas, from the latitude of Henzada southwards, are partly of this type, but it forms mainly a strip on the eastern edge of the forests, whilst Evergreen Dipterocarp Forests prevail in the interior. Epiphytes and climbers are usually abundant.

HABITAT. Typically it would seem with a rainfall between 80 and 95 inches, but the Arakan Forests enjoy a heavier rainfall than this (125-200 inches), but suffer from very poor soils—shallow and porous. On lower hills up to 3,000 feet.

DISTRIBUTION. Over large areas in the southern part of the Pegu Yomas as an intermediate stage between Wet Dipterocarp Forest and Moist Teak Forests. The type has been described in the Nyaunglebin Circle by H. W. A. Watson (25) and in

L6. Moist Teak Forest. *Tectona grandis* and *Bambusa polymorpha* (Kyathaung Bamboo). View from Panhlete Bungalow, Tharrawaddy Division. Rainfall: 60—70. Geology: Peguan, probably mixed sandstones and shales. Season: June (1921). Photo: H. R. Blanford.

the North Zamayi Reserve by A. H. M. Barrington (2) as well as in the Thabyu and Magayi Reserves (Rangoon Plains Forests) (23). The type is found in the northern part of Tenasserim (16), over considerable areas of South Arakan (Barrington), western parts of Henzada and Bassein Districts; there mainly as fringe forests, noted above (33).

L6 Moist Teak Forests (*Kurz: Moister Upper Mixed or Moister Teak Forests; Tectona-Xylia or Teak-Pyinkado Association.*)

Plates XV, XVI.

DESCRIPTION. Whatever may be the value of other Burmese timbers in the future, there is little doubt that teak is of primary importance at the present time. The teak is practically restricted to the two types of forest now to be considered—the Moist and Dry Teak Forests. The associated bamboo affords the best distinction between the two. It has already been pointed out that the greater quantity of teak occurs between the isohyetal lines of 40 and 80 inches. The Moist Teak Forests occur in the wetter half. A popular fallacy exists as to the relative abundance of teak. It very rarely occurs pure, and indeed rarely exceeds 10% of the total number of trees. Its constant associate in the Moist Teak Forests is pyinkado *(Xylia dolabriformis)*, which is often numerically more important, especially in Lower Burma. Other associated trees include:—

yon *(Anogeissus flabellifer)*, gyo *(Schleichera trijuga)* myaukchaw *(Homalium tomentosum)* hnaw *(Adina cordifolia)* bambwe *(Careya arborea)*, nabe *(Odina wodier)*, pyinma *(Lagerstroemia* sp.*)*, kanyin *(Dipterocarpus alatus* and *D. turbinatus)* (the three latter in damper localities), padauk *(Pterocarpus macrocarpus)*, thinwin *(Milletia pendula)* kathit *(Erythrina ovalifolia)*, nagye *(Pterospermum semisagittatum)* and petwun *(Berrya ammonilla.)*

In the north-eastern regions the number of associated species is very much smaller (eg. in Katha, Bhamo and Mogok); pyinkado is less important, its northern limit being about the Indaung Reserve (lat 24°5′ N). Among the more important associates are yon, gyo, nabe together with yemane *(Gmelina arborea)* and thadi *(Bursera serrata.)* The forest which has been described along water courses on the Indaung Circle (Mogok) and the fringe forests of the neighbouring Yinke Reserve seem to belong here, additional trees in this region are hnaw, *(Adina cordifolia)*, *Terminalia belerica* and *Elaeocarpus bracteatus.* Where the forest spreads on to limestone in these northern regions certain curious modifications occur but teak seems to like the rich dark soil often formed there on limestone provided the drainage is good.

Moist Teak Forests may not lose their leaves until the end of March or even later; others may, however, be partially bare early in February. The characteristic bamboos of the Moist Teak Forest are kyathaung (*Bambusa polymorpha*) and tinwa (*Cephalostachyum pergracile*). In the northern regions kyathaung is largely replaced, it would seem, by wabo-myetsangye (*Dendrocalamus hamiltonii*) also by thaik (*Bambusa tulda*) or wapyu (*Dendrocalamus membranaceus*). In Thaungyin (Northern Tenasserim) on the Siamese border Lawton (16) notes wagok (*Oxytenantha*

albociliata) as the characteristic bamboo. As a general rule, at least in the Pegu Forests it may be stated that Teak trees associated with kyathaung have a clear bole-length of up to 60 or 80 feet (compare Dry Teak Forests.)

HABITAT. A rainfall of 60″ or 70″ to 80 or 90″ in northern Tenasserim up to 100″. Teak flourishes best in a well drained, loamy deep soil, such as furnished by fine grained Peguan Sandstones (Pegu Yomas).

DISTRIBUTION. Over very large areas in the Pegu Yomas, also in Western Thayetmyo (especially as fringes), Katha, Bhamo and Mogok and Northern Tenasserim. The majority of the reserved forests in the Chindwin Districts seem to approximate to the Dry Teak Forest type. The Moist Teak Forests have been amply described in working plans by H. R. Blanford (4, 5) S. F. Hopwood, (12, 13) A. H. M. Barrington (2, 3) G. R. Jeffery (14,15) W. Lawton (16) H. W. A. Watson (25, 26) and others.

L7 Dry Teak Forest (*Dry Deciduous Forest with Teak; Kurz: Drier Upper Mixed or Drier Teak Forest; Tectona-Terminalia Association or Teak-Taukkyan Association.*) Plate XVII, figs. 1 and 2.

DESCRIPTION. It will have been noticed in the description of the Moist Teak Forests that many of the trees there associated with teak are those more at home in still moister types of forest. In dealing with the Dry Teak Forests it will be noticed that many of the associates of teak there are those more characteristic of Indaing or Semi-Indaing and other drier types.

The Dry Teak Forests are far more influenced by geology and soil than those types occurring under a much heavier rainfall and this necessitates some sub-division. Broadly the Dry Teak Forests fall into these geographical groups:—

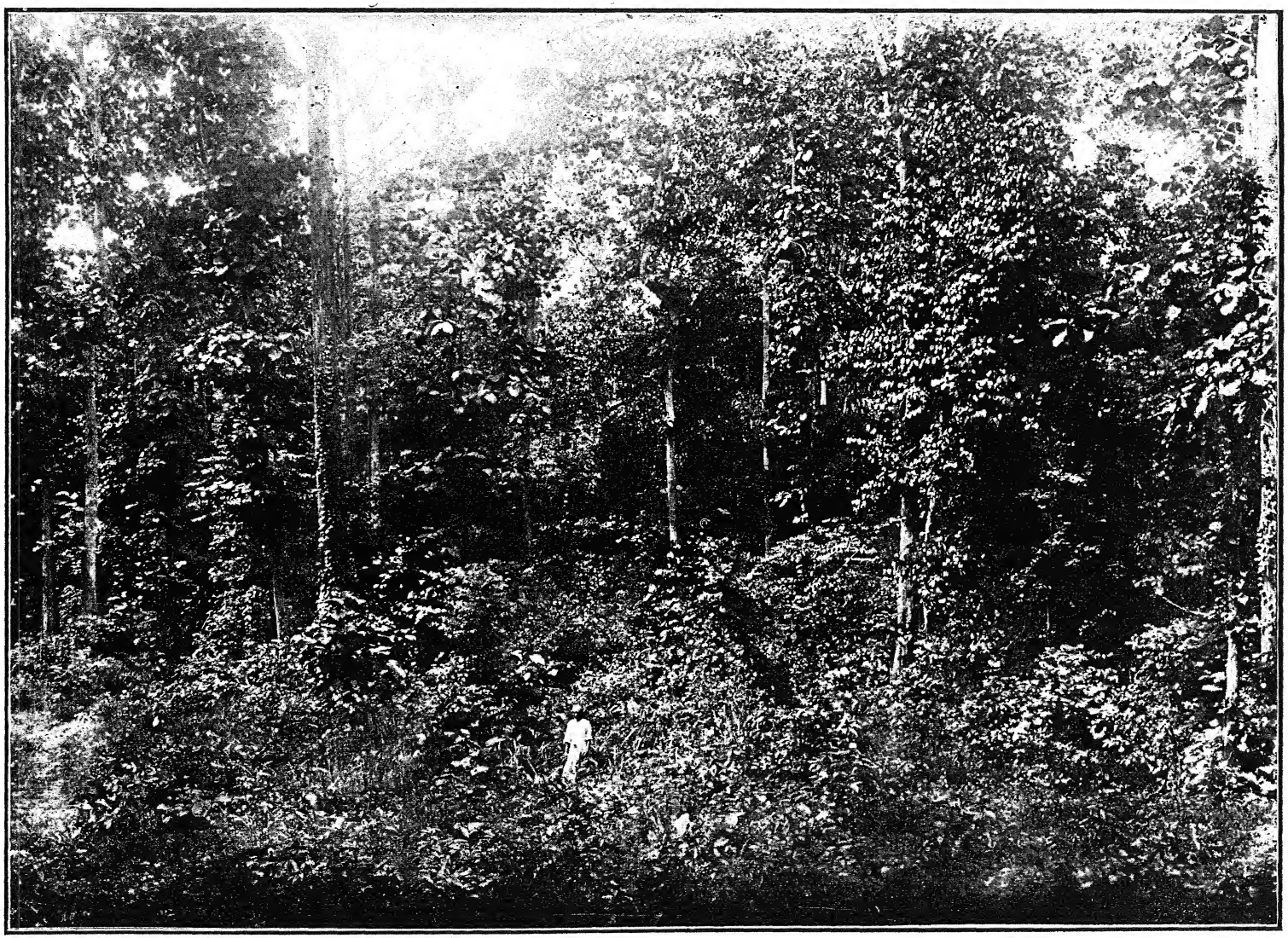
(a) Northern part of the Pegu Yomas.

(b) W. Pakokku, Chindwin and Forests of the Shwebo Hills.

(c) North-East (Katha, Mogok).

There are some differences between the forests of (a) and (b) but not sufficient to prevent their being considered together and they both occur on Tertiary sandstones and shales. The group (c) occurs on ancient gneisses and schists and limestones and exhibits such differences as to warrant separation. The following description applies to groups (a) and (b).

Dry Teak Forests are characterized almost everywhere by the presence of the bamboo, myinwa *(Dendrocalamus strictus)*. Its absence is quite exceptional. The following bamboos occur less abundantly and more sporadically and are by no means always present:—thaik *(Bambusa tulda)*, kyathaung *(B. polymorpha)* and tin *(Cephalostachyum pergracile.)* Thaik seems characteristic of the more clayey soils, especially in the Pegu Yomas. In some areas there are patches, sometimes of considerable



L6. Moist Teak Forest. General View. Near Zibyubin, North Toungoo Division. Rainfall: about 70″.
Geology: Peguan Beds. probably sandstone. Photo: A. Rodger.

Figs. 1. and 2. L7. Dry Teak Forest. *Tectona grandis*, *Anogeissus acuminata* and *Dendrocalamus strictus* (myinwa). Near Kodugwe. Rainfall: about 70″. Geology: Peguan shaley clays. Season: 22nd March 1924. Photo: L. Dudley Stamp.

extent, of Bamboo Brake *(Dendrocalamus strictus)* in the midst of the Dry Teak Forest as on some shaley hills. Teak trees associated with myinwa have a clear bole length of 30—40 feet. Compare Moist Teak Forests.

Amongst the trees of the Dry Teak Forest taukkyan *(Terminalia tomentosa)* is often numerically the most important. Teak *(Tectona grandis)* and pyinkado *(Xylia dolabriformis)* may occur in about equal proportion but usually the latter is less important. Another constant associate is padauk *(Pterocarpus macrocarpus)*. In the drier parts (as in the East Yoma Forests) pyinkado may branch near the ground and padauk frequently does. In these drier situations the following are constant associates: thitya *(Shorea obtusa)*, ingyin *(Pentacme suavis)* and even cutch *(Acacia catechu)*. Such an association marks the transition to Semi-indaing and Indaing (sandy soils). The transition (on loamy soils) to the *Vitex* Forests is marked by the presence of didu *(Bombax insigne)*, *Sterculia colorata*, nabe *(Odina wodier)*, *Vitex peduncularis*, *Vitex* spp. myaukchaw *(Homalium tomentosum)*. Such associations have been described from the East Yomas Forests by Rodger (20) and from the Gangaw and Thingadon-Yama-Patolon Forests by S. F. Hopwood (11, 12).

An important tree in the northern forests (Chindwin and Shwebo) would appear to be hnaw *(Adina cordifolia)* and sometimes yinma *(Chukrasia tabularis)* is worthy of remark.

Turning to the Dry Teak Forests of the North Eastern parts of Burma, including in particular the Tagaung Circle and the Wapyudaung Circle, the subsoil is either limestone or gneiss over large areas. Jeffery says quite definitely " The geology of this area is interesting.....as the subsoil.....is the determining factor of the actual kind and type of forest which is to be found." He states the limestone alone produces a rich dark soil eminently suited to teak whereas granite, gneiss and limestone mixed with "volcanic" soil support only Indaing. The poorer teak forests have myinwa (abundant) or *Bambusa tulda* and the teak is associated with ingyin, thitya and pyinkado. On the light rich loam covering the limestone the Teak Forest should perhaps be classed as Moist Teak as it includes pyinkado and some padauk whilst the characteristic bamboo is thana *(Thyrsostachys oliveri)*. Other trees are hnaw *(Adina cordifolia)*, didu *(Bombax insigne)*, letpan *(Bombax malabaricum)*, gwe *(Spondias mangifera)*, *Terminalia tomentosa*, *Cassia fistula*, *Sterculia* sp., gyo (*Schleichera trijuga)* yon *(Anogeissus flabellifer)*. A thorny undergrowth of *Harrisonia bennettii* and *Cratoxylon prunifolium* is frequent and climbers are numerous. Similar forests occur in the main valleys (i.e. regions below 2,500 feet) in the Northern Shan States but have been very imperfectly described (1). See Note above p. 20. and Plate V.

HABITAT. The Dry Teak Forest occurs under a rainfall of from almost 40 inches upwards. 37 inches is the lowest fall under which teak seems to grow, at least in the lower Irrawaddy tract, but the teak is there entirely stunted. The upper limit is more difficult to state as the distribution of Dry Teak Forest is very largely dependent on soil. Poor sandy soils with a rainfall as high as 75 may be covered by Dry Teak Forest but where a rich loamy soil is present Dry Teak will give place to Moist Teak at 50 or 55 inches. The best soil for teak is undoubtedly a well drained light

loam and such a soil is afforded by the Peguan sandstones. Teak rarely flourishes on clay unless the latter is ameliorated by lime (as in parts of Western Thayetmyo).

DISTRIBUTION. Northern part of the Pegu Yomas, Western Thayetmyo, Minbu, Pakokku. Most of the Chindwin Forests, situated on the light sandy soils produced by the Pondaung Sandstones and other Eocene Sandstones, belong to the Dry Teak type[1]. Occurs also on limestones of Katha and valleys in the Plateau Limestone of the Northern Shan States. Small areas occur on the Siamese border in Northern Tenasserim (16). Descriptions of Dry Teak Forest are found in most of the Working Plans listed in the Bibliography (1, 2, 6, 10, 11, 12, 14, 15, 16, 20, 21, 24, 26.)

L8 Pyinma or Plains Forest (*Kurz: Lower Mixed Forest.*)

DESCRIPTION. This type of forest was recognised long ago by Kurz. It occurs under similar conditions to the Moist Teak or Pyinkado Forests but is found on level tracts, often of alluvium. It is characterized by the presence of pyinma *(Lagerstroemia* spp.*)* as the dominant genus. Some five species of *Lagerstroemia* may be noted—*L. flos-reginae, L. parviflora, L. tomentosa, L. floribunda, L. macrocarpa.* The soil is often water-logged and sour and the presence of *Terminalia tomentosa* var. *coriacea* in such a "physiologically dry" soil is interesting, since *Terminalia tomentosa* is characteristic of the physically dry soils of the Indaing. Indeed both taukkyan (*T. tomentosa*) and lein (*T. pyrifolia*) may be looked upon as indicating that the soil is too poor and dry (physically or physiologically) for teak. Teak may occur in almost pure woods both in Upper and Lower Burma but is ill-formed, buttressed or with fluted stems. Such pure teak woods may occur on almost any alluvial flat in a bend of a stream anywhere where the climate is suitable. Occasionally where the soil is sandy or coarse enough to be well drained teak of excellent quality and size may occur. The forest is typically without bamboo, but thaik may occur. Watson (26), in his general survey of the Pegu Yoma forests notes the following trees in addition to those cited above: kanyin *(Dipterocarpus alatus)*, thitsein *(Terminalia belerica)*, panga *(T. chebula)*, lein *(T. bialata)*, binga *(Stephegyne diversifolia)*, nabe *(Odina wodier)*, bambwe *(Careya arborea)*, zinbyun *(Dillenia pentagyna)*, yindeik *(Dalbergia cultrata)*, *D. purpurea* and yon *(Anogeissus acuminata)* Three others may be noted especially where the type begins to pass into L6—thitpok *(Dalbergia Kurzii)* myaukchaw *(Homalium tomentosum)* and kabaung *(Strychnos nux-vomica).*

HABITAT. See above.

DISTRIBUTION. The plains and alluvial flats bordering the Pegu Yoma Forests and to some extent in Tenasserim. The type does not seem to occur in the northern half of Burma probably as a result of the relatively small areas of suitable flat land, moreover the northern limit of pyinma and allied species is not much north of Naba (lat 24° 12′ N).

[1] The gentle dip slopes of these beds, especially at higher elevations will only support indaing or stunted growth, as the water runs off immediately or soaks rapidly to levels below the reach of the trees.

L9-10 Semi-Indaing and Indaing (*Dry Dipterocarp Forests; Kurz: Eng or Laterite Forests; including Hill Eng Forests; Dipterocarpus-Pentacme Association.*) Plates XVIII and XIX.

DESCRIPTION. In some respects the Dry Dipterocarp Forests (Semi-Indaing and Indaing) are as typical of Burma as are the Teak Forests. Semi-Indaing occurs under rather moister or more favourable conditions than true Indaing, and forms a transitional stage to the Dry Teak Forest. The number of species in these forests is much smaller than in the damper forests, and In or Eng *(Dipterocarpus tuberculatus)* often forms well marked consociations or almost pure forest. The following are the most characteristic trees:—

Semi-Indaing (Ingyin-Thitya Forest): ingyin *(Pentacme suavis)*, thitya *(Shorea obtusa)*, taukkyan *(Terminalia tomentosa)* and in *(Dipterocarpus tuberculatus)*.

Indaing (In Forest): in or eng *(Dipterocarpus tuberculatus)*, thitsi *(Melanorrhoea usitata)*, taukkyan (*Terminalia to mentosa*) and ingyin (*Pentacme suavis*).

In the Semi-Indaing some teak, pyinkado, padauk, nabe and yon may occur, whilst in the poorer types than *(Terminalia oliveri)* and te *(Diospyros birmanica)* are often common.

Considering the large proportion of the characteristic trees—in, ingyin, thitya and taukkyan—it is unwise to stress the occurrence of others which may be present but perhaps hmanni *(Gardenia erythroclada)* may be noted. Semi-indaing and Indaing differ little in general characters over the whole of Burma where they occur, but in the north-east, especially on different soils, the subsidiary species are rather different and include not only *Strychnos nux-vomica* but also zibyu *(Cicca macrocarpa)*. Moreover Indaing passes up very naturally into Oak-Chestnut Forests and transitional stages are numerous.

Bamboos are frequently absent over very large areas of the Indaing. Where they occur myinwa *(Dendrocalamus strictus)* is typical; only occasionally do tin and others appear. The undergrowth is more often a tangle of rich grass, with a characteristic cycad *(Cycas siamensis)* and sometimes *Phoenix paludosa* (in Mogok). In the richer types (at least where the writer has studied these forests in Prome) *Pollinia articulata* is the characteristic grass; in the poorer types it is replaced by *Andropogum contortus* Linn. Despite the smaller number of species of trees In is the only one which can be described as forming consociations. Mr. C. R. Robbins (19) who has studied these Dry Dipterocarp Forests in detail in Upper Burma (Shwegu) is of the opinion that In is either a comparatively recent immigrant or a recently-evolved species in Burma and that it is rapidly spreading at the expense of the ingyin.[1] The marked consociations of In in the Indaing would then represent the areas in which it has become predominant. In has very large leaves, even the seedlings, and these keep the light away from the smaller leaved Ingyin seedlings. Now Ingyin is essentially a light demander throughout its existence and cannot propagate itself where In seedlings

[1] On the other hand in the North Toungoo foothills it is being replaced by bamboo (thaik) and by Dry Deciduous Forest. In seedlings, with their ring of dormant beds, recover very easily from fire and soon sprout. This is probably an important factor in their spreading in some localities.

cut off the light from the ground. In the broad cleared area along the telegraph line from Prome to Taungup, where it begins the main ascent to the Yomas, the writer observed this process going on; only a few In in the surrounding jungle, but its seedlings quite predominant in the cleared area.

As a general rule Dry and Wet Dipterocarp Forests have no connexion but in the Upper Chindwin with a rainfall of about 80 inches Robbins (18 a) notes the occurrence of Indaing over dry ridges and Wet Dipterocarp Forest with kanyin *(D. laevis?)* over most of the lower ground.

HABITAT. It has usually been stated that the Indaing occurs on a laterite soil. That is not strictly true. The most usual soil is a very light sandy soil—pure sand—very often such as is afforded by the Irrawaddian sands. Iron is frequently present in considerable quantity and by capillary action and evaporation may become concentrated in the surface layers as a hard pan. This hard pan is, however, very different from the ordinary cellular laterite such as is formed under much wetter conditions as around Rangoon. Indaing does occur on this true laterite but less typically. The type of soil is of great importance, rainfall less so, and the Indaing and Semi-Indaing are found growing from a minimum of 25 inches in certain small patches in the Dry Belt to about 60 or 80 inches on some of the dry ridges of the Pegu Yoma and its foothills. It is curious that much of the gneiss forming the ridge which borders the Sittang Valley on the east forms practically no soil. Its presence is marked in many places by a belt of Indaing and the latter, on this very poor gneissic soil, grows as far south as Toungoo where the rainfall must be nearly or quite 100 inches. A great part of the Ziyaing Reserve on similar soil is also Indaing, and the Hill Eng Forests of Kurz seem to be found on areas of gneiss, or other dry ridge tops even as far south as Tenasserim. Again, in Arakan where the hardened Tertiary sandstones yield very little soil the stony ridges will support only Indaing though the rainfall may be as high as 200 inches. Indaing also grows on bare limestone, as in parts of the Zibingyi Reserve between Mandalay and Maymyo.

DISTRIBUTION. Over all areas of very dry Tertiary Sands especially below 45 inches of rainfall; dry ridges elsewhere, also on physiologically dry soil in wetter regions. There are numerous descriptions of Indaing in Working Plans.

L11 Diospyros Forest (*Te Forest*).

DESCRIPTION. Under conditions of decreasing rainfall the Indaing and Semi-indaing pass quite gradually into a mixed forest, but one in which *Diospyros birmanica* Kurz (te) is especially typical. By virtue of the increasing importance of the grassy undergrowth and the less vigorous growth of trees, this *Diospyros* Forest may be classed as a Savannah Forest. In its typical form it consists of almost equal proportions of *Diospyros birmanica* (te), *Pentacme suavis* (ingyin), and *Terminalia tomentosa* (taukkyan). In the drier parts *Tectona hamiltonii* (dahat), *Dalbergia paniculata* (tapauk) and *Acacia catechu* become important. The undergrowth is almost entirely grass; three principal species have been observed and they tend to occur gregariously in patches:—

L9. Dry Dipterocarp Forest—Typical Indaing. *Dipterocarpus tuberculatus.* Kyungon, Toungoo. Rainfall: 75″. Geology: Alluvium of Sittang Valley.

Fig. 1. L9—L10. Dry Dipterocarp Forest. Large *Cycas siamensis*. Lower Chindwin. Rainfall: c 40″. Geology: Coarse Sand. Photo: A. E. Day.

Fig. 2. L9. Dry Dipterocarp Forest—Scrub Indaing. *Dipterocarpus tuberculatus, Terminalia tomentosa,* small *Cycas siamensis*. Pyaye Forest Reserve, Thayetmyo. Rainfall: c 38″. Geology: Irrawaddian pebbly sands. Season: April 1924. Photo: L. Dudley Stamp.

Andropogum contortus, A. apicus and *A. serratus.*

Level plateau surfaces often occur in the midst of this type of forest, their presence being due to concentration of iron salts in the surface layers forming a "hard pan." Practically all the rain falling on such surfaces runs off, consequently the vegetation is remarkably stunted. The principal grass in these stunted patches is *A. contortus* but there are considerable areas of hard, dry bare red soil. The arboreal vegetation often closely resembles that of the *Acacia catechu* Thorn Scrub: in other places the following occur as stunted trees:—consociations of *Pterospermum semisagittatum* and *Dalbergia paniculata,* societies of *Miliusa velutina, Diospyros birmanica* scattered bushes of *Limonia acidissima* and *Zizyphus jujuba.*

Somewhat similar patches of stunted forest occur both in Indaing and Semi-indaing.

HABITAT. A rainfall of 34—38 inches, on the very light sandy soils characteristic of the Indaing. Such light soils are the Irrawaddian Sands or the upper sandy belts in the Peguan.

DISTRIBUTION. This type of forest undoubtedly occurs over considerable areas of the Dry Belt where the rainfall is insufficient to support a growth of Indaing. The latter occurs on the same type of soil in slightly damper regions. The *Diospyros* Forest as a type was only distinguished by Stamp and Lord in 1923. It is a little doubtful whether any of the Forest Reserves include forests of so poor a type except perhaps some of the small reserves of the Meiktila Working Circle. *Diospyros* is, for example, noted as an important tree in the Daungle Reserve. S. F. Hopwood (11) describes this type of forest as a variety of the Indaing, in the Lower Chindwin Forests of Thingadon-Yoma and Patolon Circles. Mr. Smales has informed the writer that this type of forest also occurs over considerable areas of the Mu-Chindwin Watershed from East of Monywa down to the Irrawaddy and there the fruits of *Diospyros* furnish food for wandering herds of elephants.

L12 Dry Deciduous Forests with Myinwa but without Teak (*Vitex—Heterophragma Forests*).

DESCRIPTION. It has already been pointed out that where the soil is very sandy and light the Dry Teak Forest passes into Indaing and Semi-Indaing. Where, however, the soil is loamy and especially on hill sides with a rainfall of about 35 inches, the Teak Forest passes into a type of mixed forest for which it is very difficult to find a name. It was described under the term *Vitex-Heterophragma* Forest by Stamp and Lord from two of the commonest trees on the steep-sided ranges of hills —consisting of steeply-dipping Peguan Sandstones and Shales—in the Riverine tract about Thayetmyo. Somewhat similar types have been recognised in the Bhamo Division by Blanford (4, 5), in the Indaung Circle (Mogok) by A. P. Davis (8) in the Tagaung Circle (Mogok) by A. Rodger (21) and referred to as "other (non-teak bearing) dry deciduous forest with bamboo." The characteristic bamboo is myinwa *(Dendrocalamus strictus)* and the writer has noted the occurrence of Bamboo Brake

of Myinwa on exposed ridges of hill-sides. Bamboo is often so abundant as to exclude ordinary grasses. In the Thayetmyo District the following are among the many common species of trees:

Vitex cf. limonifolia, Vitex spp., *Heterophragma adenophyllum* (petthan), *Dolichandrone stipulata* (mahlwa), *Bombax insigne* (didu), *Sterculia colorata* var *fulgens, Odina wodier* (nabe), *Albizzia* spp., *Dalbergia* spp. and *Terminalia bialata.* For further details see Stamp and Lord, op. cit. p. 147.

Turning to the forests mentioned above from north-eastern Burma the following appear to be typical:—*Vitex pubescens, Vitex glabrata* (tauksha) *Terminalia chebula, Dillenia pentagyna, Eugenia* sp. *Odina wodier, Dalbergia* spp., *Erythrina* sp. The dominant bamboo is again *Dendrocalamus strictus* whilst *Harrisonia bennettii* and *Cratoxylon prunifolium* are common as undergrowth. The typical trees of the Indaing are often present. A similar forest was recently noticed by the writer on the gneissose hills east of Yamethin. Clothing the steep limestone slopes of the Shan Plateau east of Mandalay the writer and the 1923 Forestry Class of University College noted the following as dominant trees:—Kyetyo *(Vitex limonifolia)*, dahat *(Tectona hamiltonii)*, tama *(Azedirachta indica)* didu *(Bombax insigne)*, nabe *(Odina wodier)*, tabauk *(Dalbergia oliveri)*, padauk *(Pterocarpus macrocarpus)*, and palan *(Bauhinia* sp.*)*, with numerous clumps of myinwa.

HABITAT. On hill slopes with stoney, poor soils and generally from 35—50 inches of rain, but on very shallow soils may be much more.

DISTRIBUTION. Probably of wide distribution as a lateral variation of Dry Teak Forest under decreasing rainfall, but has only been recognised and described in a few parts of Burma.

L13 Dahat-Than Forest (*Tectona hamiltonii-Terminalia oliveri Forest. Thandaw of Burmans.*)

DESCRIPTION. This type of forest is very reminiscent of an English coppiced woodland on a clay-soil. The two dominants are *Tectona hamiltonii* Wall and *Terminalia oliveri* Brandis. The former usually branches near the ground, hence the coppiced effect, and does not reach an average height of more than 30 feet. *Terminalia oliveri* (than) produces straggling and ill-formed trees and very little timber of use could be obtained from these forests. The next commonest tree is *Acacia catechu* and the forest grades gradually into *Acacia catechu-Tectona hamiltonii* Thorn Forest. Myinwa *(Dendrocalamus strictus)* is common and is the only bamboo. *Dalbergia paniculata* and *Bauhinia racemosa* are frequently abundant. Conspicuous by reason of their small dark foliage and sturdy rugged stems are scattered trees of the typical Dry Zone zaung-gyan *(Osyris arborea* Willd and thamon *(Boscia variabilis* C. et H*)*. *Limonia acidissima* (thanatka) occurs commonly as shrubby bushes. The undergrowth is almost entirely grass—especially a stunted growth of *Andropogum apicus* Trin. In some localities dahat occurs almost alone as on poor soils derived from contorted shales in the Zibingyi Reserve near the 4th reversing station, Maymyo Line. In the north of the Dry Belt on the other hand Mr. C. R. Robbins informed the writer that than occurs almost alone.

On better drained slopes the trees are taller and better formed and than is of some use as a timber tree. Under such conditions transition stages to Dry Teak Forest may be found.

HABITAT. This type of forest covers large areas on stiff clays (especially Peguan Clays) with a rainfall of from 35 to 39 inches, that is, under climate conditions which do not produce the extremely unfertile " Kyatti-mye " type of soil [1] from these clays. The forest is a splendid example of a stunted and xerophilous forest produced by a physiologically dry soil. It occurs side by side with the Indaing (on the totally different sandy soil afforded by the Irrawaddian sands) and so is not the direct result of low rainfall. It has also been noted, as recorded above, on palaeozoic shales.

DISTRIBUTION. This type covers considerable areas, mainly of stiff clays, on the borders of the Dry Belt. It has been described in the riverine tract of Thayetmyo by Stamp and Lord. It is not sufficiently valuable to form normally a part of a reserved forest, but a considerable area occurs in the small plains reserves of the Meiktila Circle. Writing of these reserves A. P. Davis (8) made the " Than and Dahat Forest " one of his three main types of vegetation in this region, occupying most of the Meiktila, Menyotaung, Mondaing, Myinuhle and Welaung Reserves. A considerable tract is also included in the Kyaw and Yawdwin Circle (Yaw Division) where Dawkins (10) says of his " Than Type " of forest that it " occurs . . on soil of fairly good quality but in localities where the rainfall is too light for good teak growth. Cutch is usually abundant in that forest and pyinkado fairly so." The undergrowth is described as myinwa and glass blanks occur.

L14 Sha-Dahat Thorn Forest (*Acacia-Tectona hamiltonii Association*).

DESCRIPTION. *Acacia catechu* becomes very common in the *Diospyros* Forest and as local patches in the Than-Dahat Forest. With a lower rainfall it becomes dominant occurring both as standards and as bushes, *Tectona hamiltonii* (dahat) occurs mainly as small bushy trees. Apart from dahat nearly all the trees in this forest are armed with spines or prickles. On the eastern side of the Dry Belt tanaung *(Acacia leucophloea)* is often dominant; elsewhere *Acacia pennata* is common. *Limonia acidissima* and *Harrisonia benettii* occur abundantly as shrubs and small trees; *Dalbergia paniculata* and *Bauhinia racemosa* as slender trees. A feature of this forest is the abundance of woody lianes amongst which *Bauhinia diphylla* may be specially noted. The principal undergrowth is of grass—notably *Andropogum contortus* and *A. apicus.* Sometimes the forest is very open and forms almost a savannah. None of the trees exceed about 30 feet in height.

HABITAT. Occurs on clays or loams with a lower rainfall than that enjoyed by the than-dahat forest; on sands at a still lower rainfall, i.e. less than that required for *Diospyros Forest.*

DISTRIBUTION. A common type all over the dry belt.

[1] This type of soil, the formation of which has been described by Stamp and Lord (op. cit.) is characterized by a very high alkalinity and occurs over large areas of the Dry Belt. The alkaline salts become concentrated in the soil by capillary action and form numerous little hard whitish concretions.

L15 Sha or Cutch Jungle (*Acacia catechu* Thorn Scrub.) Plate XX fig 1.

DESCRIPTION. One of the most characteristic vegetations of the Dry Belt is a sparse scrub in which *Acacia catechu*, occurring as low (four to six feet) bushes is the most characteristic plant. The *Acacia* scrub varies considerably from place to place both according to soil and according to rainfall, becoming poorer and sparser towards the heart of the Dry Belt. In the eastern part of the Dry Belt tanaung *(Acacia leucophloea)* largely replaces sha especially on level ground (Mandalay). In the drier parts on sand *Acacia catechu* is accompanied by *Tectona hamiltonii* (bushes often only 2 or 3 feet high), *Miliusa velutina* and *Jatropha gossypifolia* (all forming consociations) together with scattered *Randia dumetorum* and other spiny bushes. *Limonia acidissima* is often common, together with scattered trees of *Boscia variabilis* (thamon). In damper regions (on clay) myinwa may occur. Almost the only undergrowth is grass, but large patches of bare soil are usual. Sometimes plants with a rosette habit (eg. *Iridax procumbens)* may be noted. Amongst the characteristic grasses are *Sporobolus coromandelianus*, Kunth, *Aristida adscenscionis* Linn., *Cynodon dactylon* Pers., (doob grass), *Eragrostis major* Host., *Andropogum foveolatus* Delm, and *A. contortus* Linn.

HABITAT. The *Acacia* Scrub occurs in very many parts of the Dry Belt (where the rainfall is less than 40 inches). With a rainfall of less than 35 inches the Peguan clays weather to an extremely infertile type of soil called locally " Kyatti-mye " characterized by a very great concentration of alkaline salts near the surface. The pH concentration of the soil is always over 10. This type of soil supports only a poor *Acacia* Scrub, whereas neighbouring areas of Irrawadian sands with the same rainfall support a *Diospyros* Forest or even Indaing. The Peguan loams of the Dry Belt are often gypsiferous and so physiologically dry and support only an *Acacia Scrub*. In the heart of the Dry Belt the *Acacia* Scrub spreads on to the Irrawadian sands, as may be typically seen near Yenangyaung—that is on to a physically dry soil. In the heart of the Dry Belt it is only locally that conditions of drainage or of deep seated water-supply permit the existence of Indaing or *Diospyros* Forest. It is sometimes stated that formerly the whole of the Dry Belt was covered with forest, which has been removed by human agency. The writer considers this belief eminently fallacious. Under existing topographical and climatic conditions the region covered by *Acacia* is quite incapable of supporting a richer vegetation and certainly not forest. The theory that clearing the supposed original forest has reduced the rainfall seems untenable on meteorological grounds.

DISTRIBUTION. See above.

L16 Zizyphus Jujuba Thorn Scrub.

DESCRIPTION. This type of vegetation develops with extraordinary persistence in many parts of the Dry-Belt on poorly drained alluvial tracts and especially on land which has been cultivated (for paddy, etc.) and allowed to lie fallow for some years. *Zizyphus jujuba* (zibin) is a very prickly shrub or small tree. In the drier regions (25 inches) it forms rounded bushes about five or six feet in height—separated by bare patches of ground. In slightly damper regions it grows into a straggling

Fig. 1. L15. Acacia Thorn-Scrub. *Acacia catechu.* Sinbaungwe. Rainfall: 34″. Geology: Peguan Clays weathering to Kyattimye. Season: October (1923). Photo: L. Dudley Stamp.

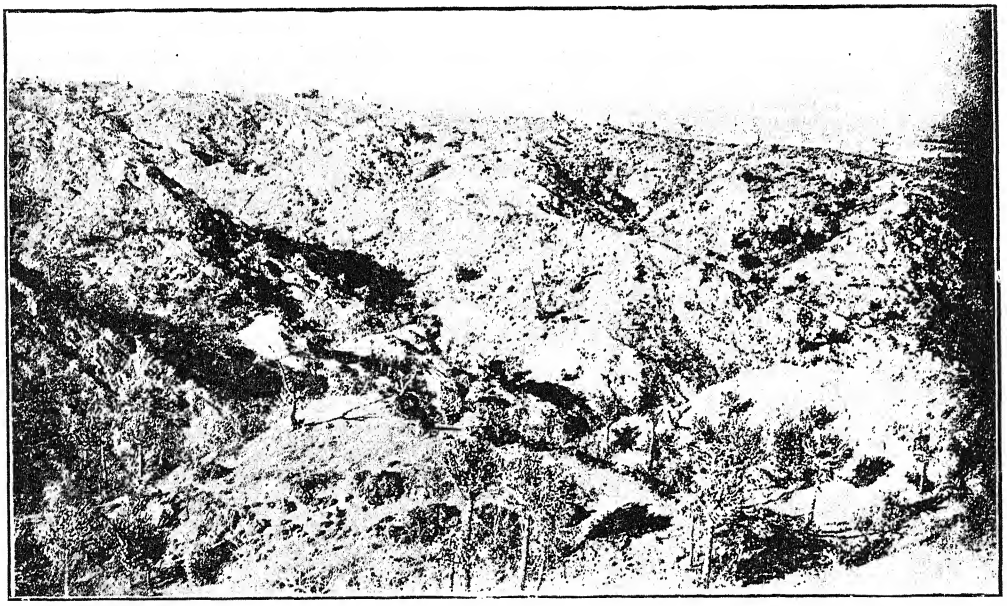


Fig. 2. L17. Euphorbia Semi-Desert. *Euphorbia antiquarum.*, Lanywa, Pakokku District. River Irrawaddy and Pagan Hills in background. Rainfall: c 20″ Geology: Peguan gysiferous clays and sandstones. Season: early May (1924). Photo: L. Dudley Stamp.

tree up to 20 feet in height. In some areas, as around Mandalay, *Acacia leucophloea* largely replaces *Zizyphus* and in other regions *Zizyphus* is associated with and may be replaced by *Capparis* spp. and here *Jatropha gossypifolia* and the Wild Castor *(Ricinus communis)* are common. In damper regions myinwa *(Dendrocalamus strictus)* is often abundant, whilst *Zizyphus oenoplia* and *Harrisonia bennettii* are constant associates throughout. In damper situations zaungbalwe *(Lagerstroemia villosa)* is common. Various herbaceous and shrubby plants occur and in damper regions numerous climbers of the orders Cucurbitaceae, Leguminoseae and Convolvulaceae unite to make an impenetrable thicket.

HABITAT. On fallows, ill-drained alluvial land or clay flats in the Dry Belt (25 to 40 inches.)

DISTRIBUTION. Throughout the Dry Belt.

L17 Euphorbia Semi-Desert or Thorn Scrub. Plate VII and XX, fig. 2.

DESCRIPTION. The type of vegetation which is characterized by the presence of fleshy, thorn species of Euphorbia is really the vegetation of a semi-desert. *Euphorbia* spp. (especially *E. antiquarum*), *Acacia catechu, Jatropha gossypifolia* are perhaps the most typical plants, in slightly damper regions *Limonia acidissima,* small *Tectona hamiltonii, Pterospermum semisagittatum, Osyris arborea, Boscia variabilis, Zizyphus oenoplia, Carissa spinarum* and *Capparis* sp. are common and a few trees of *Bombax insigne* are sometimes to be noted. The individual bushes are often far apart, the intervening ground may be bare or partly covered with the grass *Aristida adscenscionis* or one of the grasses of the Cutch Jungle. The other succulent plants which one associates with the Dry Zone of Burma *Opuntia* sp. and the Prickly Pear are largely planted.

HABITAT. On alkaline soils, especially where gypsum occurs in the subsoil and on bands of clay in the heart of the Dry Belt but not on the pure sandy soils of the Irrawadian.

DISTRIBUTION. All over the heart of the Dry Belt.

L18 Valley or Freshwater Swamp Forests (*Myaing; Kurz: Swamp Forests.*)

DESCRIPTION. In Upper Burma Swamp Forests are of limited extent and are found round marshes where the land is subjected to inundations for three or four months of the year. Interesting cases of swamp forests occur to the south of Prome in the Prome and Tharrawaddy Districts. Much of the area between the Rangoon-Prome railway line and the River Irrawaddy is inundated during the rainy season and from July to October the trees stand in some 8 or 10 feet of water. The inundated area, called the "La-ha", is probably an old bed of the Irrawaddy. Professor Unwin has informed the writer that the following are absolutely characteristic of the area—in order of importance they are:— pauk *(Butea frondosa)*, kyi *(Barring-*

tonia acutangula), sit *(Albizzia procera)*, yon *(Anogeissus* sp.*)*, tein *(Stephegyne parvifolia)* also a few *Lagerstroemia* and gyo *(Schleichera trijuga)*. The bamboo is kyatkat *(Bambusa arundinacea)*. On the whole the forest is a very open and sparse one. This area of forest is mentioned as a typical example; a more extensive study of this type of vegetation would be of great interest.

Mr. Smales informs the writer regarding swamp forests that " the most characteristic species of the very wettest places, only dry for a few weeks, are *Xanthophyllum glaucum* and *Dalbergia reniformis*, almost pure, with masses of *Combretum* and *Glochidion*." Allied to the last is the riparian vegetation of the River Irrawaddy. Here, especially on outcrops of soft sandstone, an evergreen shrub yechinya *(Homonoia riparia)* is very noticeable. It flourishes despite the fact that it is submerged for perhaps 9 months of the year. (Plate XXVII, fig. 1).

HABITAT. On alluvium, especially of the Irrawaddy Valley, and inundated during the rainy season.

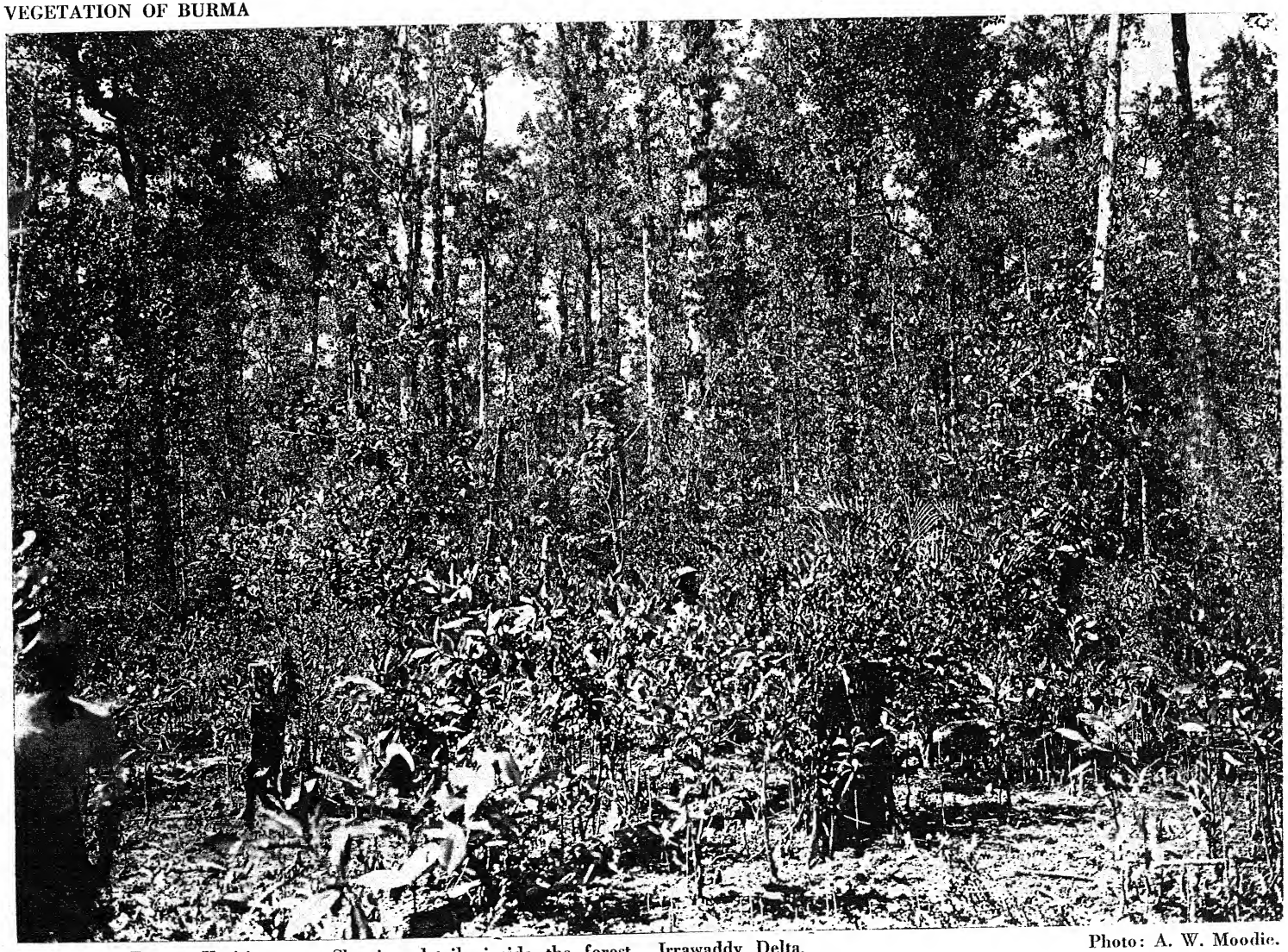
DISTRIBUTION. Notably between the Hlaing and Irrawaddy Rivers, Rainfall 45 to 80 inches.

L19 Kanazo Forests (*Heritiera Forests.*)[1] Plates I, XXI, XXII, XXIII.

DESCRIPTION. Strictly the tree should perhaps be called pinle-kanazo *(Heritiera fomes)* to distinguish it from a non-tidal tree *(Baccaurea sapida)* also called kanazo. This type of forest requires a good soil and for most of the year complete disappearance of water off the surface of the land for a few hours between tides. It does not require salt water but can tolerate it. Kanazo itself breathes through " tent-peg " excrescences which rise from the roots to a height of from 3 to 10 inches. Kanazo Forest, whilst essentially a tidal forest, occurs at slightly higher levels than the typical Mangrove or *Rhizophora* forests, and flourishes where the water is less salt. Two main varieties may be separated:—

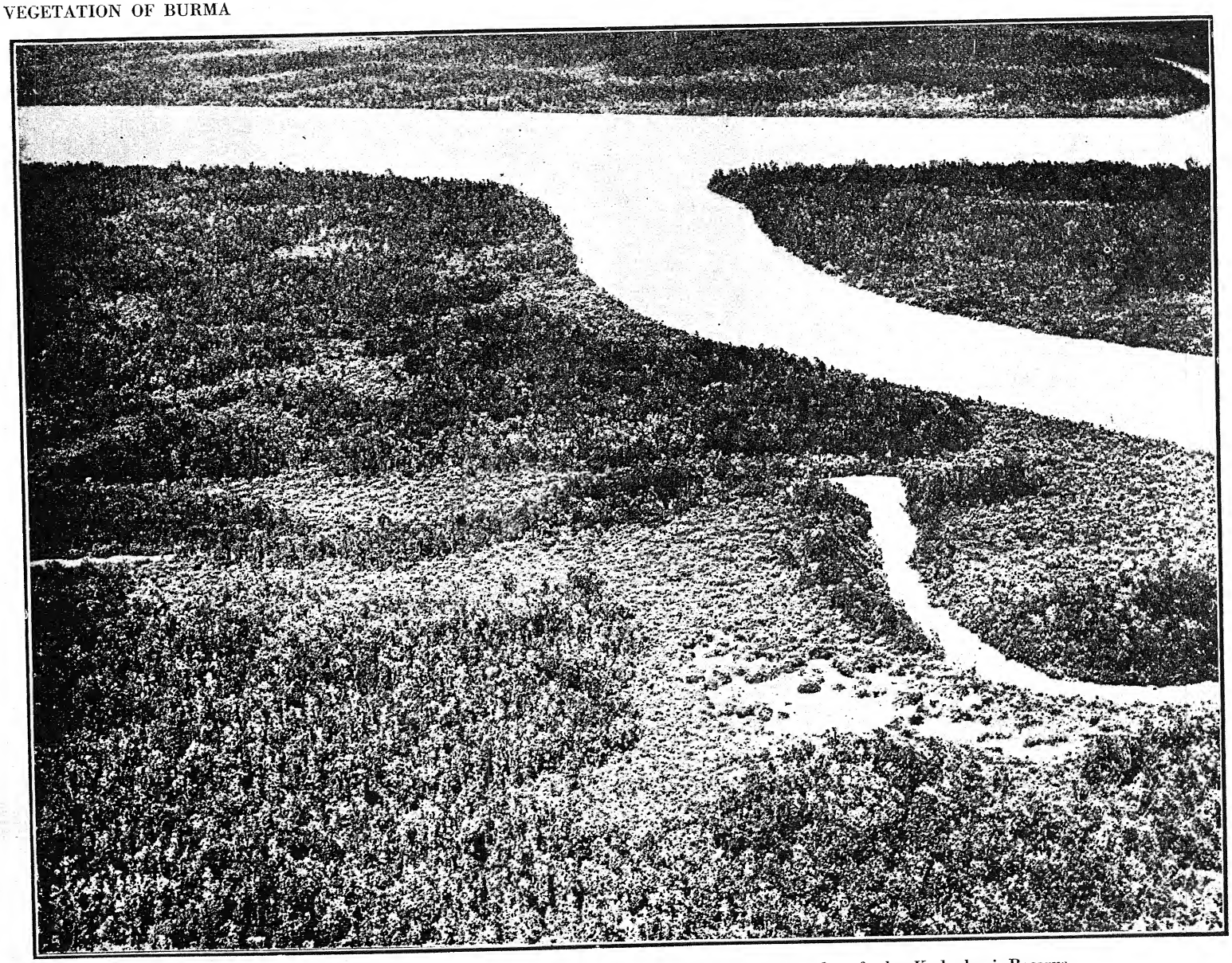
L19 a Where the water is comparatively fresh growth is more vigorous—kanazo often exceeds 100 feet—but the forest less dense. Associated species are pantagama *(Amoora cuculata)*, pantagabo *(Dysoxylum* sp.*)* sagalun *(Afzelia bijuga)*, kyi *(Barringtonia acutangula)* sauk *(Combretum* sp.*)* khaya *(Acanthus ilicifolius)* etc. At slightly higher levels (Moodie's type 4) near the upper limit of kanazo and the

[1] Moodie has recently published a detailed account of the Irrawaddy Delta Forests (17) which has been freely used in the following account. He adopts and modifies the earlier classification of English (27) and groups the Delta Forests as follows:—
(1) Inland sandy levels, not flooded, underground water fresh—Forest variety of L1 etc.
(2) Sandy levels near sea, not flooded, underground water salt—L22.
(3) Clay high levels flooded with water, mainly fresh, during the rains—L20.
(4) High intermediate levels, flooded with water mainly salt during spring tides—variety of L19.
(5) Low intermediate levels, flooded during all tides—L19.
(6) Low levels, flooded during all tides, mainly by fresh water.
(7) Low levels, flooded during all tides, by salt water—L21.
During 1923—4 an aerial survey of the Irrawaddy Delta Forests has been carried out for the Forest Department under the general direction of Major E. C. Kemp. On the aerial photographs Mr. C. R. Robbins considers it is possible to distinguish 10 types (a to j) which correspond to the types here enumerated:—(a) L19; (b) L19 worked; (c) L19c; (d) L22; (e) L20 blanks; (f) L20 a; (g) L20 b; (h) L20; (i) L21 c; (j) L21 b.



L19. Kanazo Forest. *Heritiera* spp. Showing details inside the forest. Irrawaddy Delta.

Photo: A. W. Moodie.



Oblique Aerial View of the Forests of the Irrawaddy Delta. East side of the Kadonkani Reserve. L19, Kanazo Forest and L20 Mixed Delta Scrub or Byaik.

Fig. 1. L19.—L21. In front, narrow fringe of *Sonneratia acida;* behind, Kanazo Forest *(Heritiera fomes).* River Bank, Kalayaik Reserve, Irrawaddy Delta. Photo: A. W. Moodie.

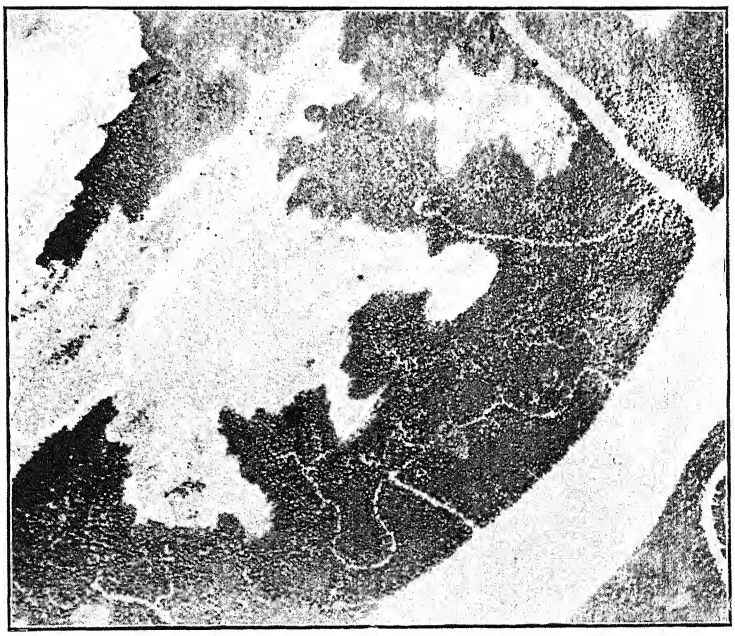
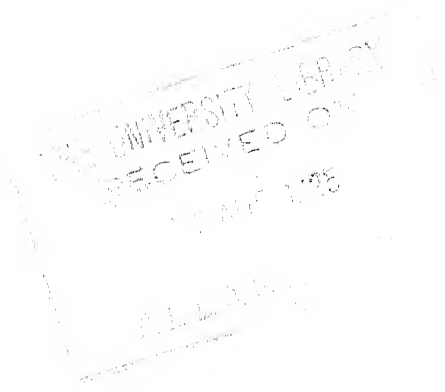


Fig. 2. L19 and L5 (?). Aerial View of the Delta Forests showing tidal forests (Kanazo) surrounding a leafless deciduous forest (showing white) occupying higher ground. Season: March (1924).



highest of the mangrove forests all aerial roots are short. Kanazo is here large and associated with large thabaw *(Pandanus foetidus)* and also with bamaw (*Litsaea sp.)* pantaga and myinga *(Cynometra ramiflora)*. The latter may occur almost pure (myinga byaik) and should be considered under L20. The transitional stages between Kanazo Forest and Myinga Byaik are marked by myinga with groups of large old kanazo trees.

L19 b Where the water is brackish the kanazo reaches only a medium girth but the stand is thicker. Associated species are few and include the true mangroves. Trees to be noted are hngetgyidaung *(Acrostichum aureum)*, kyana *(Carapa moluccensis)*, pinleon *(C. obovata)*, byu-kyettet *(Bruguiera parviflora)*, thayaw *(Excoecaria agallocha)*, laba *(Sonneratia griffithii)* salat *(Cerbera odallum)* and myinga. At slightly higher levels, flooding is less frequent and evaporation causes the soil to become impregnated with salt. As a result the forest is poor. Kanazo occurs with an understory of myinga *(Cynometra ramiflora)* and sometimes madama *(Ceriops roxburghiana)*, whilst the ground is covered with *Achrostichum aureum.*

A very important and wide spread variety of Kanazo Forest, easily distinguishable in aerial photographs is one with large scattered trees of kambala *(Sonneratia apetala)*. This may be called L19c.

HABITAT. Kanazo Forest can be killed by drowning (*e. g.* submergence throughout the whole or part of a Rainy Season) and cannot exist above the level of the spring tides of the early part of the year. Hence its limits between the two extremes. The water may be practically fresh or brackish.

DISTRIBUTION. Over several hundreds of square miles in the Irrawaddy Delta, also over large areas in Mergui and South Arakan.

L20 Mixed Delta Scrub and Low Forest (*Byaik, or strictly Kon-Byaik of Burmans.*) Plates I and XXII.

DESCRIPTION. The upper limit for Kanazo has been noted above. Above this level, on clayey soils, tree growth is scattered and poor. The principal species are poor thitpyu and myauk-on *(Lauraceae)*, panmauk-kon *(Elaeocarpus hygrophilus)*, talapi (*Calophyllum* sp.) nasha (*Litsaea*), thabye *(Eugenia)*, poor pyinma *(Lagerstroemia flos-reginae)*, *Mangifera caloneura*, te *(Diospyros* sp.*)* and pantaga *(Amoora cuculata)*. The undergrowth is thick and difficult to penetrate and consists largely of canes; thaing *(Calamus erectus)*, kyu *(Phragmites* sp.*)*, tawkunthi *(Pinanga* sp.*)* thin *(Clinogyne dichotoma)*, myaukkyein *(Flagellaria indica)*, damon *(Calamus arborescens)* and thinban *(Hibiscus tiliaceus)*. Blanks are common in the forest, consisting mainly of grass or of a dense matted mass of the last-mentioned species. Another type of byaik (L20a) is characterized by thinbaung *(Phoenix paludosa)*. Myinga Byaik (L20b) characterized by myinga *(Cynometra ramiflora)* often almost alone, is a widespread type in the Irrawaddy Delta and has been noted above.

HABITAT. Compare above.

DISTRIBUTION. Over large areas in the Irrawaddy Delta and probably over considerable tracts in Mergui, etc.

L21 True Mangrove Forests (*Rhizophora Forests.*) Plates XXIV and XXV.

DESCRIPTION. The home of the Rhizophores, which may be regarded as the true mangroves, is at a lower level than the kanazo. The slimy mud around the roots is only exposed for a few hours each day and the water is always salt (contrast kanazo). In the Irrawaddy Delta these forests are not extensive and occur as strips along the sea-face and tidal banks, often effectively obscuring the far more extensive areas of Kanazo Forests behind. The same is true of large areas in the Mergui Archipelago, though in some cases the Rhizophora swamps cover the greater part of wide mud-flats. The principal species are *Rhizophora mucronata, R. conjugata* and *Sonneratia apetala* (kambala). Other species occurring on the wide creek banks are *Bruguiera parviflora, Carapa obovata* and *Sonneratia griffithii* with some stretches of *S. acida.* The Dani Palm *(Nipa fruticans)* is common. Although agreeing in their leathery, xerophitic character, the leaves of the above species vary considerably in hue and accentuate a strong tendency towards gregariousness which the writer noted amongst these forests in Mergui.

Moodie notes as another type (L21a) a forest of pure madama with shrubs of pinlesha *(Aegialitis rotundifolia)* and khaya *(Acanthus ilicifolius).* Madama and thayaw *(Excoecaria agallocha)* may form codominants in a Forest (L21b) or the latter alone (L21c). The last two types seem to occur especially behind the sand-banks thrown up by the sea.

HABITAT. Muddy shores submerged by every tide (salt water) below the level of the Kanazo Forests.

DISTRIBUTION. Narrow fringes in the seaward half of the Irrawaddy Delta and low islands of Arakan, fringes and larger areas in the low islands of Mergui. The Mergui Islands consist either of granite (many, rocky), limestone (few) or disintegrated "Mergui Series" (phyllites). Nearly all the mangrove swamps are around the latter.

L22 Beach or Dune Forests and Sandy Sea-Shore Vegetation. Plate XXVI.

DESCRIPTION. In Tenasserim (especially in Tavoy) there are very numerous bays in which the sea has thrown up a sandy bar, cutting off an area of mangrove swamps from the sea.[1] The swamp gradually silts up—a process the writer studied at the pretty little spot known as Maungmagan (Tavoy). The sandy strip may be several hundred yards in width and is covered with creeping herbs, amongst which *Ipomoea pes-caprae* is conspicuous together with maritime grasses. Out of the reach

[1] See Coggin Brown and Heron, *Mem. Geol. Surv. India,* Vol. XLIV, pt. 2, 1923, p. 201.

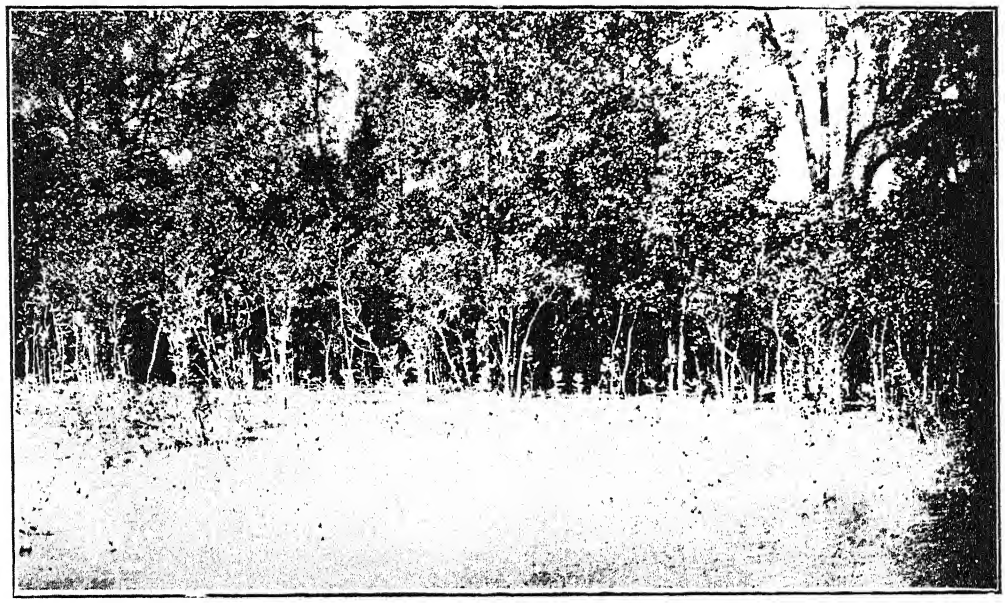


Fig. 1. L19—L21. Mangrove Swamp Forest, Low Tide. Island opposite Mergui. Trees in background mainly *Heritiera* and *Ceriops;* in foreground *Aegialitis rotundifolia.* Notice rhizophores sticking up through the mud in the foreground. Feb. 1924. Photo: L. Dudley Stamp.

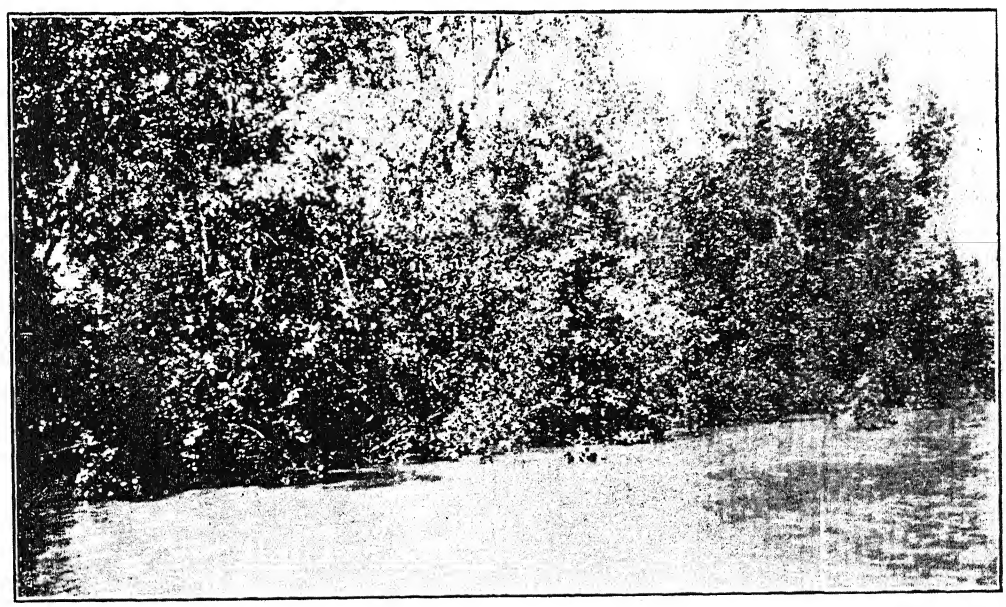


Fig. 2. L19—21. Mangrove Swamp Forest. As last 3 hours later (High Tide). Notice only just the crowns of *Aegialitis* are above water. Photo: L. Dudley Stamp.

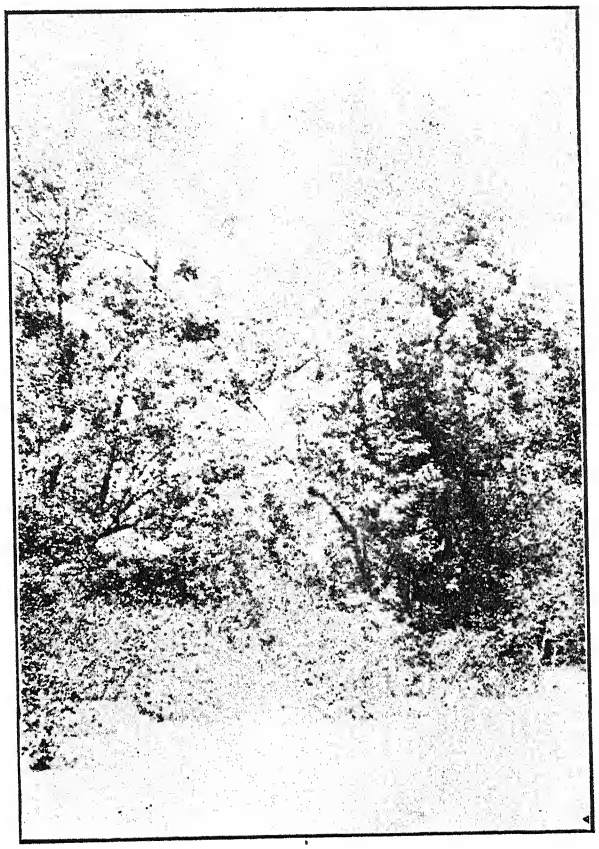


Fig. 1. L21.—L19. Mangrove Swamp Forest. Island opposite Mergui. General View at High Tide. Feb. 1924. *Heritiera, Ceriops roxburghiana, Sonneratia acida.* Photo: L. Dudley Stamp.

Fig. 2. L21. Mangrove Swamp. *Nipa fruticans.* High Tide. Mergui. Feb. 1924. L. Dudley Stamp.

Fig. 3. L21. Mangrove Swamp Forest. Mergui Archipelago. General View at half tide. Mainly *Rhizophora.* Feb. 1924. L. Dudley Stamp.

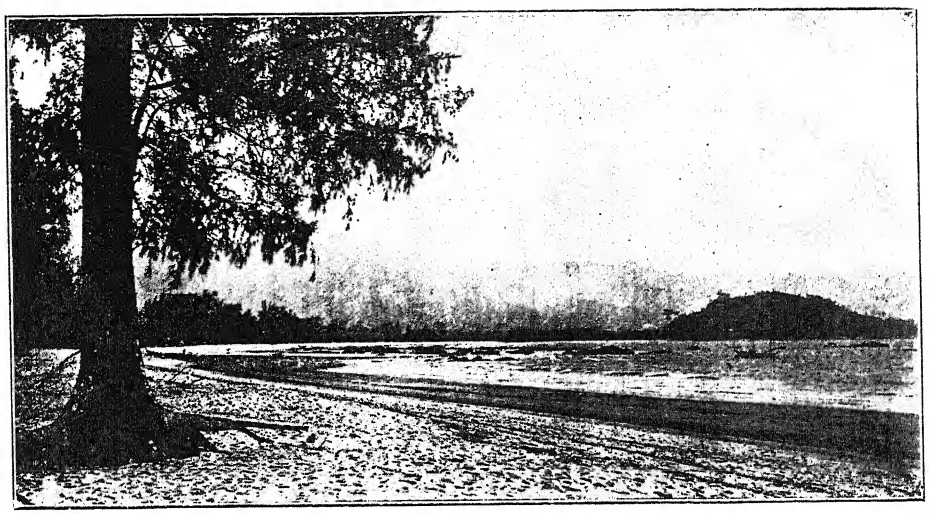


Fig. 1. L22. Casuarina Dune Forest. Photo: M. Inui Studio.

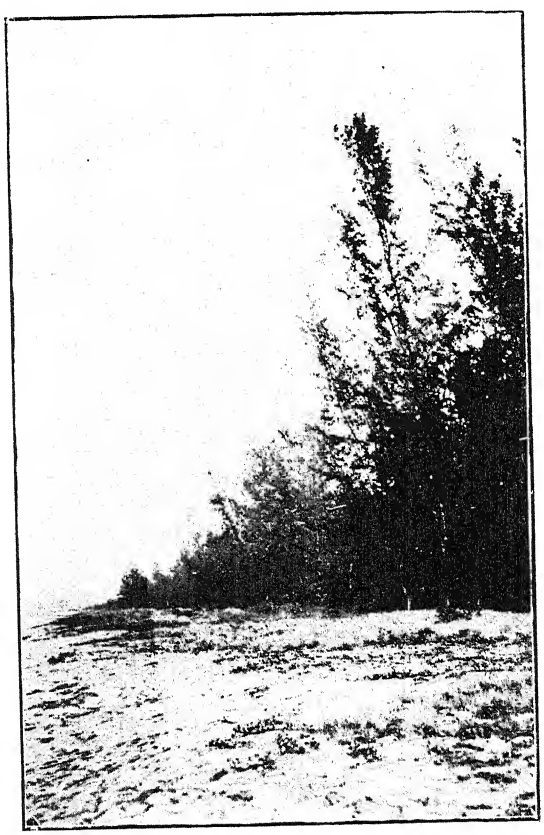


Fig. 2. L22. Casuarina Dune Forest. Photo: L. Dudley Stamp.

Figs. 1. and 2. are both at Maungmagan, Tavoy. Rainfall: probably 170″—200″. Geology: Recent marine Dune Sands. Season: (Fig. 2): early March (1924). In Fig. 1. notice the granite hills with evergreen forest (L1); in Fig. 2 notice *Ipomaea* and maritime grasses.

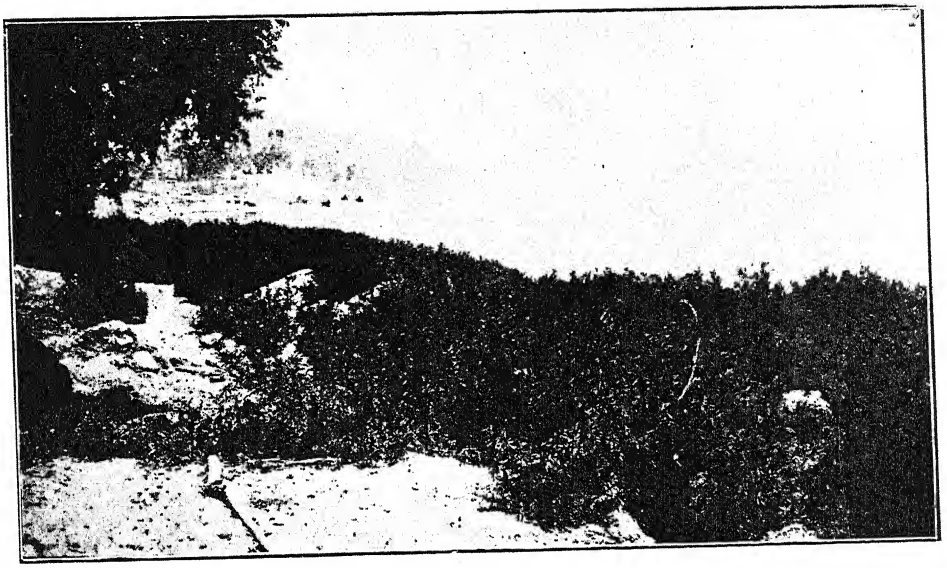


Fig. 1. L18. Riparian Vegetation of River Irrawaddy, Low Water Season. This rich growth of *Homonoia riparia* is completely submerged for at least 6 months annually. Geology: Irrawaddian coarse sands. Peikthalein, Thayetmyo. Season: March (1924). Photo: L. Dudley Stamp.

Fig. 2. S3. Riverside Parkland, Thayetmyo showing the effect of clearing, and encouraging or planting species which can thrive with a low rainfall. Centre and left: *Tamarindus indicus*. Foreground: *Enterolobium saman*. Rainfall: 38″. Geology: Irrawaddian Sands. Season: 6th June (1924). Photo: L. Dudley Stamp.

of the highest tides is a narrow strip of the graceful Casuarina trees *(C. equisetifolia)*. Similar sandy margins occur on the sea-face of a considerable part of the Irrawaddy Delta with grass, *Ipomoea* and *Canavalia obtusifolia* but the trees there are sit *(Albizzia procera)* myatya *(Grewia microcos)* and thabye *(Eugenia* sp.*)*

HABITAT. See above.

DISTRIBUTION. L22a *(Casuarina)* coasts of Arakan and Tenasserim. L22b, sea-face of Irrawaddy Delta. The Casuarina belts have a wide distribution outside Burma and are noted by Mr. G. E. S. Cubitt (Statements prepared for the British Empire Forestry Conference, Canada, 1923—Malay Peninsula and Brunei) as occurring along the east coast of the Malay Peninsula and uninterruptedly along the coast of Brunei.

L23 Salt Marsh Vegetation.

DESCRIPTION. Although excellent opportunity occurs for studying this vegetation near Rangoon, so far as the writer is aware no attempt has been made to do so. Some characteristic fleshy plants may be seen on the borders of the Rangoon River below Monkey Point.

L24 Fresh-Water Swamp Vegetation.

DESCRIPTION. Here again is a great field for study as little can be added to Kurz's general statements. Distinction should be made between permanent swamps and those which are dry in the hot weather.

L25 Lake Vegetation.

The great abundance of the water-soldier *(Stratiotes)* is often remarkable, water-lilies *(Nymphaea)* are common: *Eichornia crassipes* (Bedabin or water-hyacinth) has spread over Upper as well as Lower Burma and is fast becoming a serious pest in the delta creeks, impeding navigation. *Vallisneria* and *Lemna* are common in all lakes.

SERAL COMMUNITIES.

It is convenient to use the term of the American ecologist, F. E. Clements, to embrace those vegetations which have not reached the natural climatic climax for the locality in which they are found.

S1 Kaing Grassland (on Sandbanks).

DESCRIPTION. One of the most familiar sights to the traveller on the River Irrawaddy are the sandbanks covered with Kaing or Elephant grass (a general name including such species as *Saccharum spontaneum*). As soon as the sand is more or less fixed by these grasses various herbs appear and, when the sandbank is, for various reasons, not subject to annual flooding, trees appear and give a savannah like appearance to the landscape. It seems useless to attempt a further description of this vegetation until the plant succession can be properly worked out.

S2 Combretum Hedgerow Community.

DESCRIPTION. At least in the Dry Belt and on its borders Stamp and Lord noted that *Combretum apetalum* so constantly appeared in hedgerows and comparatively infrequently elsewhere that they separated a hedgerow community. In drier regions it is associated with *Capparis, Ricinus communis, Opuntia, Cactus,* and other succulent plants.

S3 Riverside and Village Parkland. Plate XXVII, fig. 2.

DESCRIPTION. In many parts of Burma a pleasing parkland appearance has been produced by clearing away undergrowth, shrubs and small trees and leaving only a few standards. Forest exploitation has produced similar savannah land over large areas. Around villages many trees are planted for shade and other purposes and present such a characteristic appearance as to be confused with natural vegetation.

S4 Ponzos.

DESCRIPTION. This name is given to land which, after having been under temporary cultivation (taung-ya cultivation), is being allowed to return to natural jungle. It slowly returns to forest, or possibly would do, but in many cases tall grasses or bamboo spring up, preventing tree growth. The plant succession in ponzos is a huge subject in itself and cannot be dealt with here. In ordinary ponzos (in Monsoon Forest) at first a mass of *Blumea* and woody species of *Solanum* may spring up "giving place quickly to thickets of *Grewia, Buddleia asiatica, Ficus, Trema,* etc. in which the faster growing species of the neighbourhood struggle up till they can get their heads free and oust the others, the first to do this being often *Duabanga* and *Albizzia*" (Smales). Of late years the alarming spread of the plant "bizat"—*Eupatorium odoratum,* has made the whole process much slower. In some cases grass is important, in drier areas a thorny scrub springs up (probably L16, the Ziziphus Thorn Scrub should be included here.) Further, the area may be permanently invaded by bamboo or in higher regions by bracken.

IV. GEOLOGY AND ECOLOGY.

The description of the plant communities of Burma which has been given above would be incomplete without some remarks on its application to matters of practical importance. A very large proportion of the wealth of Burma comes from its agriculture and forestry. The artificial vegetation of a country—that is really its agriculture—is controlled by climate and soil no less than its natural vegetation. Any successful attempt at the introduction of new crops into Burma, as well as the extension of the area under existing crops must of necessity involve, whether we recognise it under that name or not, the study of the ecological relationships of the crops concerned. A study, even a simple study, of the ecology of the natural vegetation supplies an enormous amount of information. The writer's collaborator in ecological work in Burma (Mr. L. Lord, I.A.S.) commenced this interesting and valuable study but sufficient work has not yet been done to permit of any generalisation. Taking just the borders of the Dry Belt, however, there may be noted in the Thayetmyo District such relationships as these:—

(1) clearings (taungyas) in Vitex Forest on Peguan Sandstones are suitable for wagyi cotton.

(2) clearings in a rich type of Sha Dahat Thorn Forest on Red gravels are also suitable for wagyi.

(3) clearings in *Diospyros* Forest seem suitable for groundnuts.

(4) clearings in Sha Thorn Scrub are suitable for groundnuts or sesamum when on sands but not when on clays.

(5) clearings in Sha Thorn Scrub are suitable for levelling, clearing away of surface soil and irrigation for paddy when on Peguan clays but not when on sands (i.e. the opposite of ground-nuts.)

There is an immense field for study here.

Turning now to forestry, several authors have realized the remarkable control which the geology exercises on the type of forest. It was clearly realized by Kurz, despite the fact that when he studied the flora, the Father of Burmese geology (W. Theobald) had not published his famous essay on the Geology of Pegu. It speaks well for the clear thinking of Kurz that he realized the connexion between forestry and geology in a country which had as yet no published or other account of its geology. In more recent years Jeffery remarked strongly on edaphic control in the Mogok forests, and it has been commented on by several observers in various odd places. It is only, however, when one attempts to map the geology and vegetation side by side that the close affinity is realized. Two pairs of maps will suffice to illustrate this point.

The first is taken from the work of the writer and Mr. Lord. The geology was mapped by the writer. the vegetation by both authors. The maps are self-explanatory. Figs. 5 and 6.

The second is chosen because of its diversity of origin—the geological map is from one published by the writer, whereas the vegetation map is taken from one of the Working Plans prepared by the Forest Service. Figs. 7 and 8.

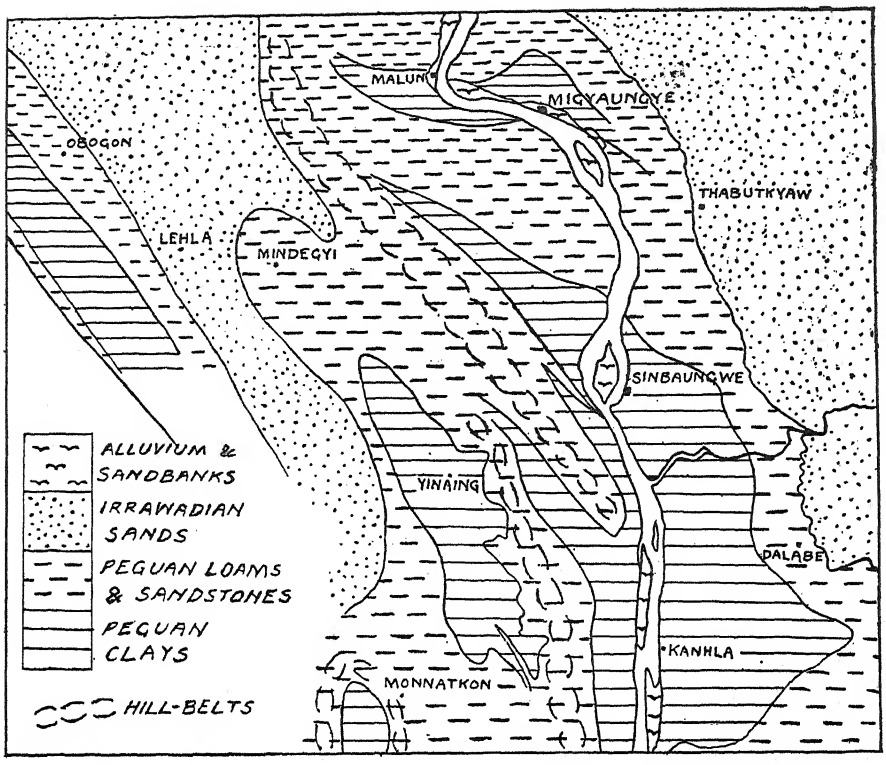


Fig. 5. Geological map of part of the Irrawaddy Valley within the borders of the Dry Belt. Scale 8 miles=1 inch. L. D. S.

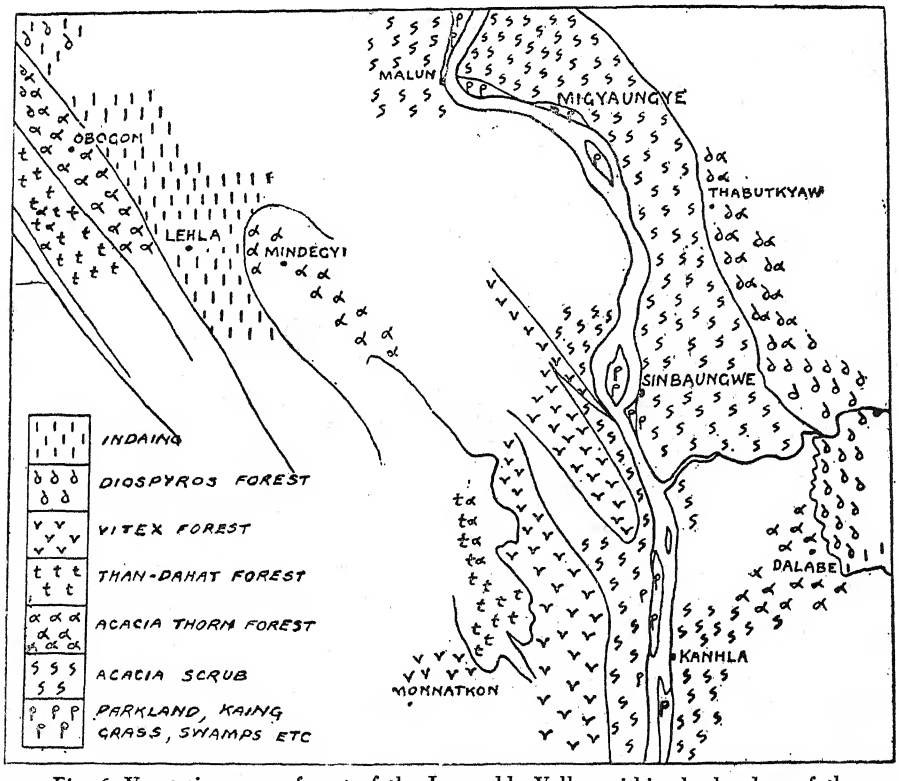


Fig. 6. Vegetation map of part of the Irrawaddy Valley within the borders of the Dry Belt. Scale 8 miles=1 inch. L. D. S. and L. L.

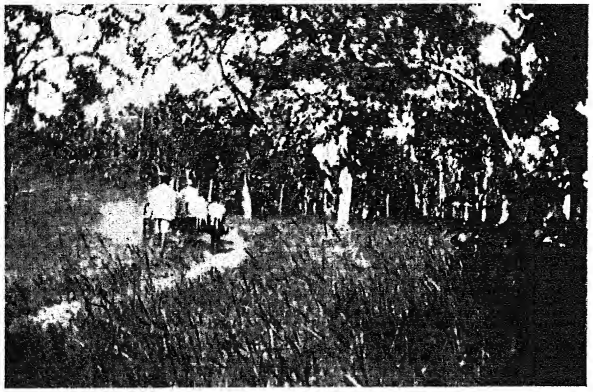


Fig. 1. L9-10. Indaing. Near Padi, north-west of Prome. Rainfall: c 45″. Geology: Irrawaddian sands.

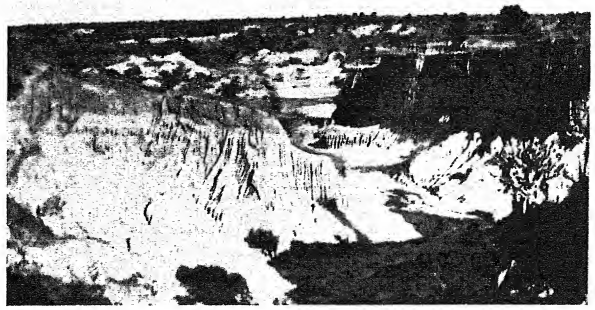


Fig. 2. L17. *Euphorbia* Semi-Desert and L15, *Acacia* Thorn-Scrub. North of Yenangyaung. Rainfall: c 22″. Geology: Irrawaddian sands identical with Fig. 1.

Fig. 3. L15. *Acacia* Thorn-Scrub. Sinbaungwe. Rainfall: c 34″. Geology: Peguan Clays weathering to Kyattimye. Weathering in early stages.

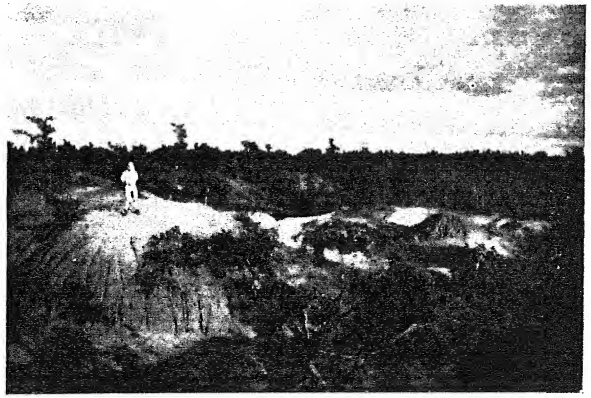


Fig. 4. L15. *Acacia* Thorn-Scrub. Sinbaungwe. Rainfall: c 34″. Geology: Peguan Clays weathering to Kyattimye, with large bare areas.

Figs. 1 to 4. Illustrating Edaphic Control in the Dry Belt. Photos: L. Dudley Stamp.

The second pair of maps really illustrates two important points. In the first place the way in which the Teak Forest follows the outcrop of the Yaw Shales just below the main scarp of the Mahodaung Range shows how one type of vegetation will follow the outcrop of a geological formation which yields a suitable soil. But in the second place it also illustrates the tremendous importance of the *dip* of the strata. The two main lines of hills in this area—the Pondaung Range and the Mahodaung Range have long gentle dip slopes on the west and abrupt scarp slopes on the east (fig. 9). Both consist of rather coarse porous sandstone. Any rain which falls on the top of the range very rapidly runs off or sinks quickly through the porous sandstone. Consequently the rocks or soil of higher parts of the dip slope are always very dry and hence covered with Indaing. But the water which has here sunk into the ground comes out elsewhere; much of it follows along the bedding plains and issues lower down the dip slope—hence the moister forest lower down the dip slope —but part of it follows along joints and cracks and issues as a series of springs along the scarp face which is kept continually damp—hence the moister forest on this side. These points are illustrated in the sections. Figs. 9 and 10.

At first sight it seems that the forests of the Pegu Yomas entirely contradict all that has just been said. The reversal of effects there is due to two main causes (1) the Peguan sandstone of the Pegu Yomas are much finer grained, yield a good soil, and hold water—they are assisted in so doing by clay partings—and so remain moist; (2) the beds of clay are shaley, impervious and afford a very poor soil. Taking just the main crest of the Pegu Yomas there is a long gentle slope on the east and a steep scarp slope on the west. The long dip slope consists of fine grained sandstone which is continually moist and hence is clothed with moist forest; the steep scarp slope consists of infertile clays which once they have absorbed water will not give it up and hence are physiologically dry and clothed with a dry type of forest. Similar conditions are seen in the shaley Kodugwe valley and the sandy ridges on either side. These points are illustrated in figs. 11 and 12.

Provided the climate is known, it is not too much to say that given a geological map of the country, [1] a very great deal will be already known (a) regarding possibilities of afforestation, whether by planting or by encouraging natural regeneration (b) regarding possible crops for cleared areas. This applies especially to areas with a rainfall of less than 80 inches.

Finally there is one point worthy of mention. That is the immense amount of valuable ecological data which can be gathered by anyone who will take the trouble to travel with a map and a local village cooly. Many a weary trek through the jungle, when one's pace may be limited by the $1\frac{3}{4}$ miles per hour of one's bullock-carts can be much enlivened by taking an intelligent interest in the vegetation. In rural Burma every villager knows the native names of the trees in the neighbouring jungle, and it is a matter of very little trouble or difficulty to note down the native names (to be looked up at leisure) of the trees and to identify the main plant-associations and note their positions on the map.

[1]See Appendix I.

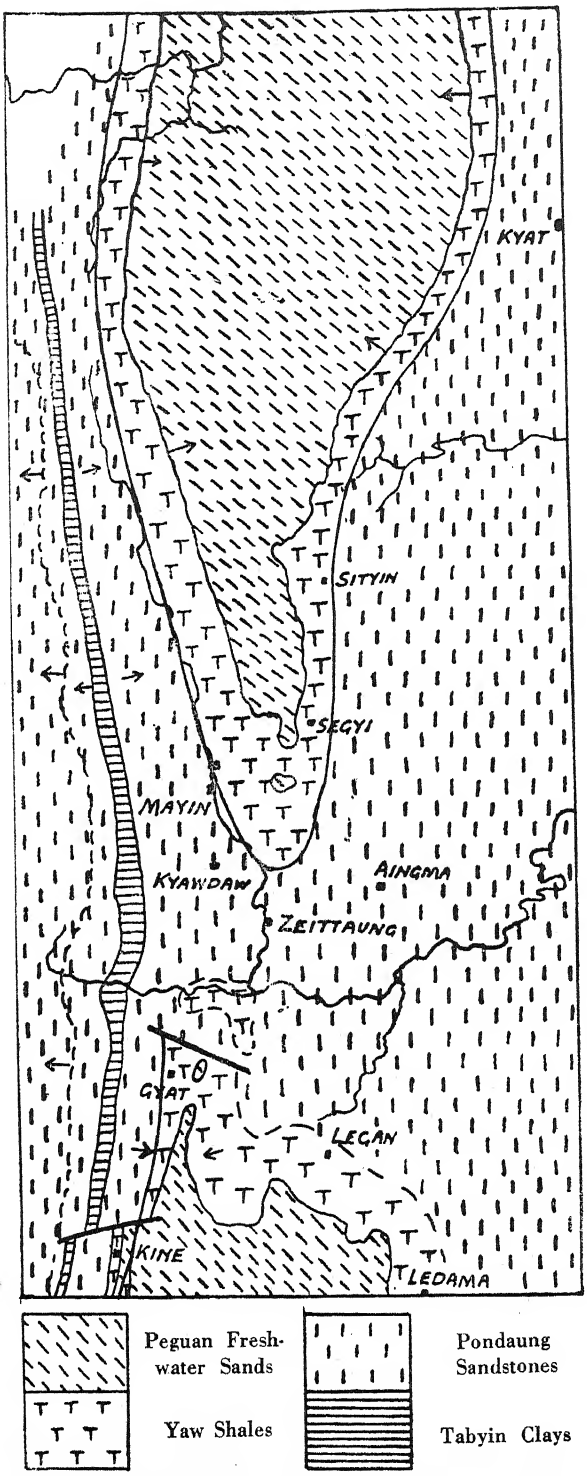


Fig. 7. Geological map of part of the Lower Chindwin District. Scale 5 miles=1 inch. *L. D. S.*

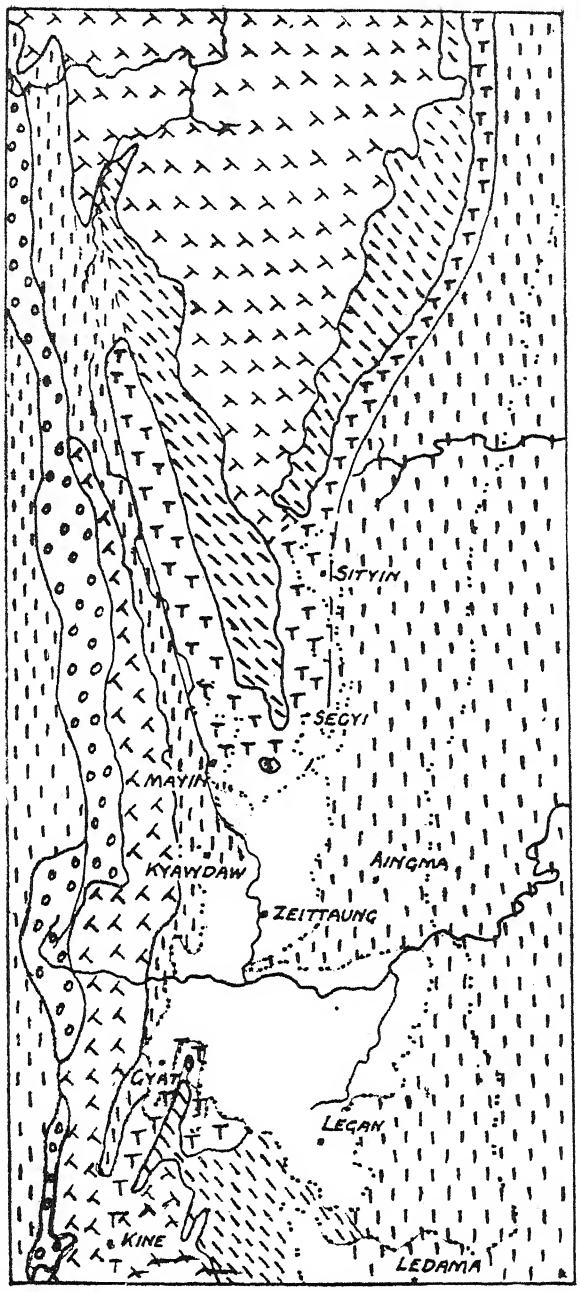


Fig. 8. Vegetation map of part of the Lower Chindwin District (Legan, North Yoma, Sindon and East Patolon Forest Reserves). Scale 5 miles=1 inch.

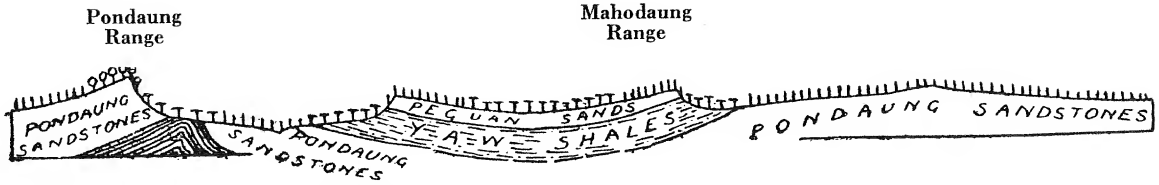


Fig. 9. Geological and Vegetational section across the maps shown in Figs. 5 and 6. I=Indaing; T=Teak Forest. For explanation see text. *L. D. S.*

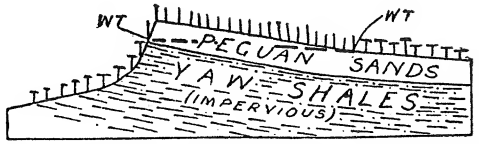


Fig. 10. Section showing details of the central part of Fig. 9. WT=water table. Rain falling on the ridge sinks rapidly through the porous sand (hence the dry Indaing, I) but issues lower down at the points marked WT and WT hence the moister Teak Forest. *L. D. S.*

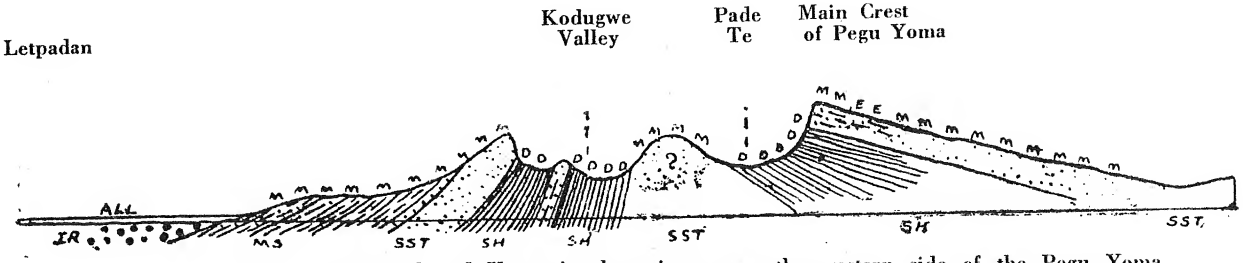


Fig. 11. Geological and Vegetational section across the western side of the Pegu Yoma. Geological:—all=alluvium, Ir=Irrawaddian, remainder is Peguan comprising MS (mixed sandstones and shales), Sst (sandstone), Sh (shales). Vegetation:—M=Moist Teak and Pyinkado Forests; D=Dry Teak Forests; E=Evergreen. Notice the Dry Teak Forest on the infertile shale belts.

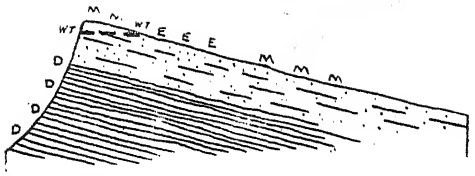
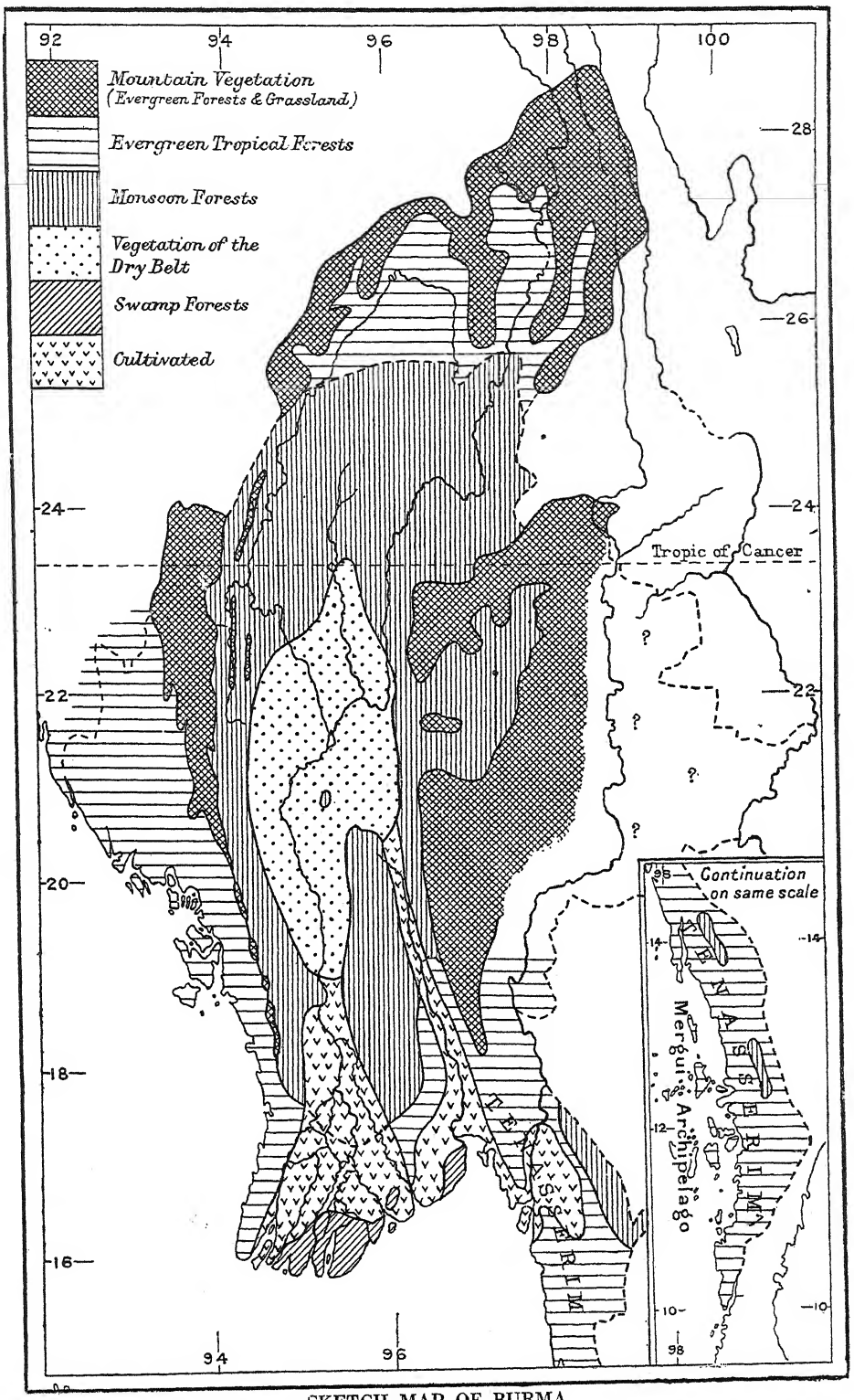


Fig. 12. Section showing details of the main scarp of the Pegu Yomas. Notice on the steep scarp slope the Dry Forest due to the shaley soil; rain falling on the main crest does not sink far down owing to the finer nature of the sandstone and the occasional partings of shale; it tends instead to run down the gentle dip slope (to the east) near the surface. Hence the moist or evergreen Forests there.
L. D. S.



SKETCH MAP OF BURMA

showing very approximately the distribution of the main groups of vegetation types. Reproduced, by permission, from the Geographical Journal, September, 1924. (*Vide*: Stamp, L. Dudley, Notes on the Vegetation of Burma, *Geog. Jour.*, Vol. LXIV (1924) pp. 231-7. In this paper the habitat of Kanazo *(Heritiera)* should be described as roughly between highest low-water mark and lowest high water mark).

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The writer is very much indebted to Mr. F. A. Leete, C. I. E., late Chief Conservator of Forests, Burma, for permission to look through all the existing Working Plans. In each of these are introductory remarks on the forests themselves and, whilst the timber-trees of known or presumed value loom largely in the accounts, much information of general value to the ecologist may be gleaned. There is, unfortunately, practically no information on non-arboreal vegetation except of those species regarded as pests by the forester. Out of the numerous working plans studied the following are listed as the most interesting to the ecologist:—

(1) 1916 Barrington, A. H. M., Bawgyo Working Circle, Hsipaw.

(2) 1916 Barrington, A. H. M., North Zamayi Reserve, Pegu F. D.

(3) 1924 Barrington, A. H. M., North Toungoo.

(4) 1911 Blanford, H. R., Mohnyin, Katha.

(5) 1913 Blanford, H. R., Mosit, Bhamo.

(6) 1919 Blanford, H. R., Yomas Reserves in the Tharrawaddy Div. Vols. I and II.

(7) 1907 Carter, H., Maymyo Fuel Reserve.

(8) 1917 Davis, A. P., Plains Reserves, Meiktila Working Circle.

(9) 1918 Davis, A. P., Indaung Working Circle, Mogok.

(10) 1917 Dawkins, C. G. E., Kyaw and Yawdwin Working Circles.

(11) 1915 Hopwood, S. F., Thingadon-Yama and Patalon Working Circle Lower Chindwin.

(12) 1916 Hopwood, S. F., North and South Gangaw Working Circles.

(13) 1918 Hopwood, S. F., Saing Working Circle, N. Toungoo.

(14) 1909 Jeffery, G. R., Hintha Working Circle, Ruby Mines.

(15) 1916 Jeffery, G. R., Wapuydaung Working Circle, Ruby Mines.

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(22) 1905 Rorie, J. J., Plains Forests, Rangoon F. D.

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(31) 1921 Rodger, A., A Hand-Book of the Forest Products of Burma, Superintendent, Government Printing, Rangoon.

(32) 1921 Rorie, J. J., The Bhamo-Kachin Hills, (A note, printed for the Forest Dept., not for publication).

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(36) 1923 De, R. N., Assam to Burma across the Hills, *Indian Forester*, Vol. XLIX, Oct. 1923, pp. 529-537.

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Apart from official publications of the Indian Forest Service, it is to be noted that Brandis, De, Gamble, Hopwood and Troup are or were all officers of that Service.

APPENDIX—GEOLOGICAL MAPS.

In view of the importance attached in this book to the study of geology as a basis for soil-investigation and ecology, the following list of maps available has been drawn up. The Geological Survey of India have mapped geologically a considerable part of Burma on the scale of one inch to one mile. The maps are hand coloured and may be seen at the offices of the Geological Survey in Calcutta or at their branch office in Rangoon and any map may be copied. The staff of the Survey will also supply copies hand coloured at reasonable rates. In the same way maps on the scale of 4 miles to one inch may be obtained. The maps on smaller scales i.e., 16 miles and 32 miles to the inch respectively are of very little use for ecological purposes.

The maps have not, of course, been made expressly for foresters and are often not detailed enough for his purpose. Thus the Peguan rocks, which yield a variety of rock types and soils are usually coloured as one. However, the maps give the broad outlines of the geology and form a valuable basis for more detailed work which the forester with some training in geology can supply. The maps available (June 1924)[1] are as follows:—

Scale one inch to one mile.

84 J/4, J/8, J/12.

84 K/1, K/2, K/3, K/4, K/5, K/6, K/7, K/8, K/9, K/10, K/11, K/12, K/13, K/14, K/15, K/16.

84 L/1, L/2, L/3, L/5, L/6, L/7, L/8, L/9, L/10 and 14, L/12 and 16, L/13.

84 O/2, O/10, O/14.

84 P/1 and 5 (=153), P/2 and 6 (=154), P/4 and 8 (=156), P/9 and 13, P/10 and 14.

85 I/5, I/13, I/10 and 14 (=114), I/11 and 15 (=115), I/12 and 16 (=116).

85 M/1 and 5 (=157), M/2 and 6 (=158), M/3 and 7 (=159), M/4 and 8 (=160).

85 N/1 and 5, N/2 and 6, N/4 and parts of 85 J/16 and N/8, N/7 and J/15.

85 O/1 and 5, O/2 and 6.

93 C/2, C/3 and 7, C/4 and 8, C/6, C/7, C/9 and 13.

93 D/1 and 5, D/2 and 6, D/3 and 7, D/9 and 13, D/10 and 14.

93 F/9 and 13, F/13, F/14, F/15.

95 J/1 and 5, J/2, J/3, J/4, J/7, J/8, J/12, J/16.

95 K/1, K/4 and 8, K/5, K/6, K/7, K/9, K/10, K/11, K/12.

95 L/1 and 5, L/6, L/7, L/9, L/10, L/11, L/12, L/13, L/14, L/15, L/16.

[1] List kindly supplied by the Superintendent-in-charge, Burma Party, Geological Survey of India.

95 O/1, O/2.

95 P/3, P/4.

96 I/5 and 6, I/9, I/10, I/13, I/14.

96 M/1, M/2, M/5, M/9.

Scale 4 miles to one inch.

84 J, K, L, O, P.

85 M, I and M.

93 C, D.

94 A.

The following most useful and valuable sheets covering a great part of the Northern Shan States are published as plates illustrating T. H. D. La Touche's 'Geology of the Northern Shan States,' *(Mem. Geol. Surv. India;* Vol. XXXIX, pt. 2, 1913—out of print) but may be copied:—93B and part of C; 93F; 93J (part).

In addition to the coloured sheets listed above, there are many maps which have been printed and published in the 'Memoirs' and 'Records' of the Geological Survey. Where the maps have been published in this way, coloured copies are not as a rule kept of the original sheets in the Rangoon office.

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